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THE AMERICAN JOURNAL OF ROENTGENOLOGY

VOL. IX [NEW SERIES] DECEMBER, 1922 No. 12

THE SCIENTIFIC BASIS OF SHORT WAVE-LENGTH THERAPY*

THIRD CALDWELL LECTURE

BY WILLIAM DUANE, PH.D., SC.D.

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RECENT advances in *x*-ray therapy have emphasized the great importance (*a*) of employing very penetrating radiation and (*b*) of accurately estimating dosage. More than eight years ago, I began studying the conditions necessary to produce penetrating *x*-radiation that would approach as nearly as possible the gamma radiation from the radioactive substances. About that time, the fundamental researches of Laue, Friedrich and Knipping, and the Braggs became generally known. The results of their investigations indicate that we may regard an *x*-ray as consisting of a series of waves following each other at a certain definite distance. We call the distance from one wave to the next the wave-length of the *x*-ray. Recently, the general public has become familiar with the idea of waves and wave-lengths in connection with wireless telegraphy and wireless telephony. Each broadcasting station sends out wireless waves of a certain definite wave-length. We hear, for instance, of wave-lengths of 400 meters (a little more than 400 yards) etc. This means that successive waves in the wireless wave train follow each other at a distance of 400 meters, etc. Researches in physical science have shown that wireless waves, light, *x*-rays and gamma rays consist essentially of the same *kind* of waves: further, that they differ from each other only in the lengths of their waves. Whereas wireless waves are usually several hundred meters long, light waves and *x*-rays have lengths of only a very small fraction of a centimeter. The lengths of *x*-rays ordinarily used amount to only a few billionths of a centimeter. Immediately after the discovery of the fact that *x*-rays had wave-lengths, it became evident that we should become accustomed to thinking and speaking of *x*-rays in terms of wave-lengths instead of in terms of voltages, of absorption coefficients, of "hardness" or of any of the suggested penetrometer scales. Following out this idea, I began immediately to investigate the wave-lengths produced under different experimental conditions—to investigate what we call the spectrum of the *x*-rays produced by various tubes and by various methods of exciting them, etc. I purpose in this lecture to give a brief résumé in non-technical language of some of these researches.

2. Before passing on to the main subject matter of the lecture, it may be advisable to state briefly the fundamental problem of *x*-ray therapy for those who may not have made a special study of the subject. The primary object of *x*-ray therapy in the treatment of malignant disease is the destruction of the tumor tissue by means of radiation absorbed in it. If the tumor lies some distance below the surface of the skin, the radiation projected into the

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., September 12–16, 1922.

tumor must first pass through the skin itself and the intervening tissues. The amount of *x*-radiation that can be projected into and absorbed in the tumor depends upon the tolerance of the skin and intervening tissues for the radiation.

As an illustration of deep radiotherapy, let me compare the treatment with radium rays of a tumor lying, let us say, 10 cm. below the skin, with the treatment of the same tumor with *x*-rays. The diagram in Figure 1 illustrates the two cases. Let us suppose that a quantity of radium is placed at *A*, 10 cm. from the skin of the patient, and that the tumor to be radiated lies at a distance of 10 cm. below the skin, at *B*. Evidently the tumor lies at a distance from the source of rays that is twice as great as the distance to the skin. Owing to the spreading out of the radiation as it proceeds from the source, and in accordance with what is known as the inverse square law, a given small volume of tissue at *B* would receive only one-fourth of the radiation that the same volume of tissue would receive at the surface of the skin, even if none of the radiation were absorbed by the 10 cm. of intervening tissues. The gamma rays from the radioactive substances, as they are usually employed in deep therapy, are somewhat more than half absorbed in passing through 10 cm. of tissue, so that, owing to the combined effects of the spreading out of the rays and of the absorption by the tissues, the gamma radiation reaching the tumor is less than one-eighth of that passing through an equal volume of tissue at the skin. In other words, the amount of gamma radiation absorbed by the given volume of tissue at the tumor amounts to less than 12½ per cent of that absorbed by an equal volume of tissue at the skin. This proportion might be increased somewhat by increasing the distance of the radium from the skin. To get the same effect at the tumor, however, it would be necessary to increase the quantity of radium used, or the time of exposure. Practically 10 cm. is about the greatest distance that can be used effectively with the amounts of radium now at our disposal. In *x*-ray therapy we can employ far greater distances, for the *x*-ray tube radiates very much more powerfully than any obtainable amount of radium does. The diagram *CD* in Figure 1 represents the case of *x*-ray therapy. Let us suppose that the target has been placed at a distance of 80 cm. from the skin, a quite feasible distance. We will suppose, also, that the tumor, as in the radium treatment, lies at a distance of 10 cm. below the skin. In this case, the inverse square law shows us that about 79 per cent of the radiation that reaches the skin would reach the tumor, if it were not absorbed by the intervening tissues. (80 squared divided by 90 squared equals .79.)

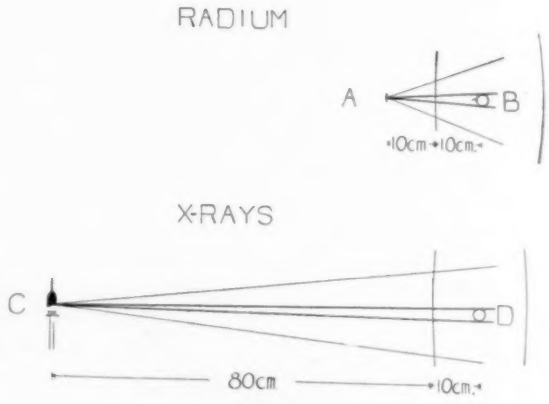

FIG. 1.

In the case of *x*-rays used in deep therapy (*x*-rays produced by 200,000 volts, or so, with heavy filtration) about four-fifths are absorbed in passing through 10 cm. of tissues. One-fifth of the radiation comes straight through the 10 cm. Hence, as one-fifth of 79 per cent equals about 16 per cent, 16 per cent of the *x*-radiation will reach the tumor, 10 cm. below the skin. Comparing this with the radium problem, we find that whereas, in the radium case, only about 12 per cent of the radiation reaching the skin penetrates directly to the tumor, 10 cm. below it, in the *x*-ray case, 16 per cent penetrates to the tumor. In other words, from this point of view, an *x*-ray tube appears to be a more effective instrument for deep therapy than a quantity of radium.

In the above problem, we have estimated the radiation reaching the tumor that travels in a direct line to it from the source of rays. In addition to this direct

radiation, a lot of secondary radiation reaches the tumor, that comes from the surrounding tissues through which the rays pass. The fact that radiation produces secondary rays was discovered over twenty years ago. The recent researches carried on in central Europe have brought out the importance of the secondary radiation in deep *x*-ray therapy. It is on account of this secondary radiation that the total radiation received by the tumor depends to so large an extent upon the portal of entry. If we use a large portal, the total radiation received by the tumor, 10 cm. below the skin, may amount to more than 50 per cent of that received by the skin itself.

So much has been published recently in *x*-ray literature about the distribution of *x*-radiation in water phantoms, etc., that it hardly seems worth while for me to do more than to call attention to the great importance of the subject. We have begun investigations of the distribution of the radiation in phantoms having as nearly as possible the sizes and shapes of the portions of the body to be radiated. We hope to check the results obtained by measurements with small ionization chambers placed at various points in among the human tissues themselves.

To sum up, three factors determine the fraction of the radiation reaching the skin that penetrates to a tumor below it:

(*a*) The inverse square law.

(*b*) The absorption of radiation by the tissues.

(*c*) The effect of secondary radiation.

The first factor is a question of solid geometry only. Its magnitude does not depend upon the kind of *x*-rays that one uses. The other two factors, however, differ in magnitude for different kinds of *x*-rays. In general, tissues absorb less radiation if the wave-length is small, than if it is large. Similarly, the secondary radiation factor depends also upon the wave-length. If the wave-length is short, a larger amount of secondary radiation will reach the tumor than if the wave-length is long. It becomes, therefore, a problem of great importance in deep *x*-ray therapy to produce *x*-rays of short wave-lengths. It has been largely for the purpose of calling especial attention to this fact that I have dwelt so long upon the elementary problem of deep therapy,

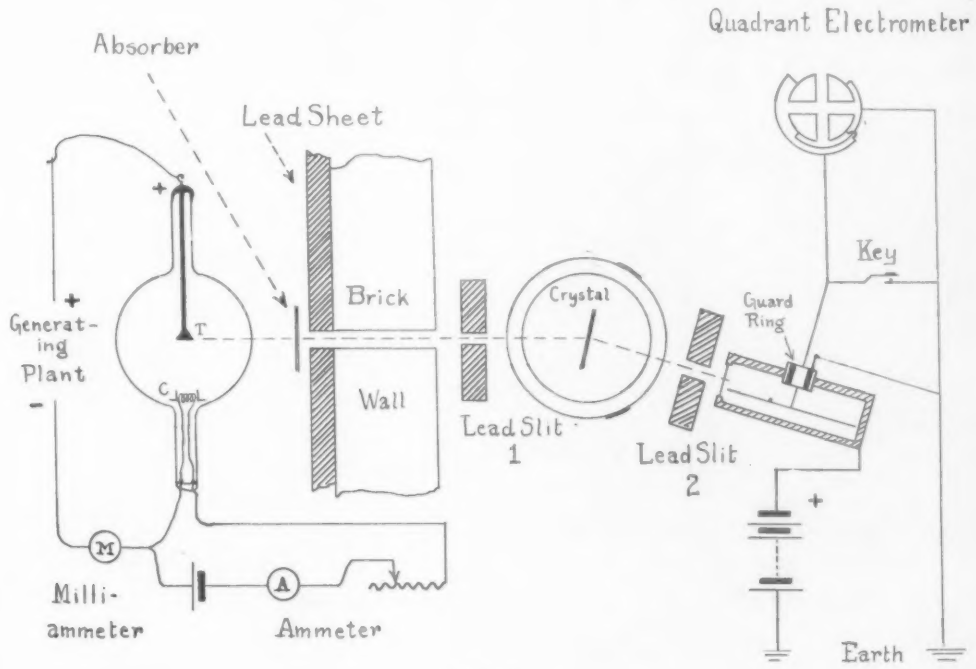

FIG. 2.

before describing our researches in *x*-ray spectra.

3. The method of measuring the *x*-ray wave-lengths is based upon the researches of Laue, Friedrich and Knipping, and the Braggs. Figure 2 represents the arrangement of the apparatus. A beam of *x*-rays coming from the target *T* passes through a small hole in the brick wall and then through a narrow slit between lead blocks. The *x*-ray tube and the generating plant lie in one room and the spectrometer in an adjoining room. The wall between the rooms gives good protection to the spectrometer and the operators against stray radiation from the tube. When high voltages are used, and, therefore, penetrating radiation, it is advisable to add a

FIG. 3.

considerable thickness of lead to increase the protection, as illustrated in the figure. The *x*-rays, after coming through the lead slit, pass through a small crystal mounted on a spectrometer table. The spectrometer table can be turned through any desired angle, and the position of the crystal determined by reading the spectrometer scales. Part of the *x*-ray beam is reflected by the atoms in the crystal. *X*-rays of certain wave-lengths only are reflected at a given angle. By measuring this angle, the wave-length can be calculated. The reflected beam of rays passes through a second lead slit into an ionization chamber, and the current produced by them is measured by the quadrant electrometer. We take the current through the ionization chamber as an indication of the intensity of the *x*-rays having the calculated wave-length.

Figure 3 is a photograph of one of our *x*-ray spectrometers. The *x*-ray tube and generating plant are in a room to the right and the *x*-rays come through the metal tube that can be seen projecting from the wall toward the spectrometer.

4. The first problem that we took up some nine years ago was to determine just what wave-lengths an *x*-ray tube produces, when operated at a certain voltage; in other words, to investigate the spectrum produced by a given voltage. The curves in Figure 4 were published by Mr. Hunt and myself in 1915. They represent the radiation at different wave-lengths from a tube operated at a *constant*

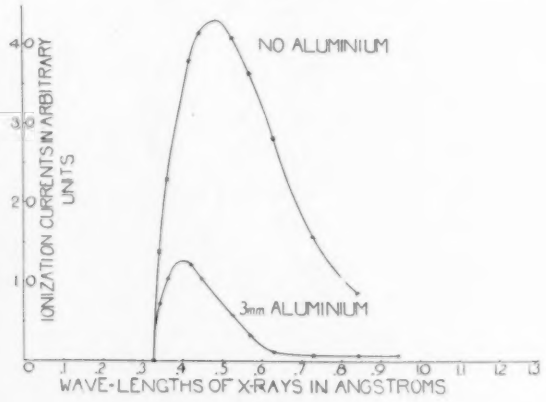

FIG. 4.

voltage. We used a high-tension storage battery to produce the current through the tube. The larger curve corresponds to a beam of unfiltered *x*-rays, and the smaller, to a beam filtered through 3 mm. of aluminum.

Three important conclusions can be drawn from these curves:

(*a*) A constant voltage applied to an *x*-ray tube does not produce *x*-rays of a single wave-length only; it produces a beam of rays having a great variety of wave-lengths.

(*b*) There is a certain minimum wave-length of the *x*-rays produced—no *x*-rays come from the tube having wave-lengths shorter than this minimum value. By making experiments at different voltages we have shown that the minimum wave-length depends only upon the voltage used.

It is always given by the law that the product of the voltage multiplied by the wave-length equals 12,354. According to this law, if we double the voltage, we halve the minimum wave-length; if we treble the voltage, we reduce the minimum wave-length to one-third its original value; etc.

(*c*) The effect produced by introducing absorbing materials in the path of the rays (filtration) is to decrease the intensity of the longer waves to a greater extent than

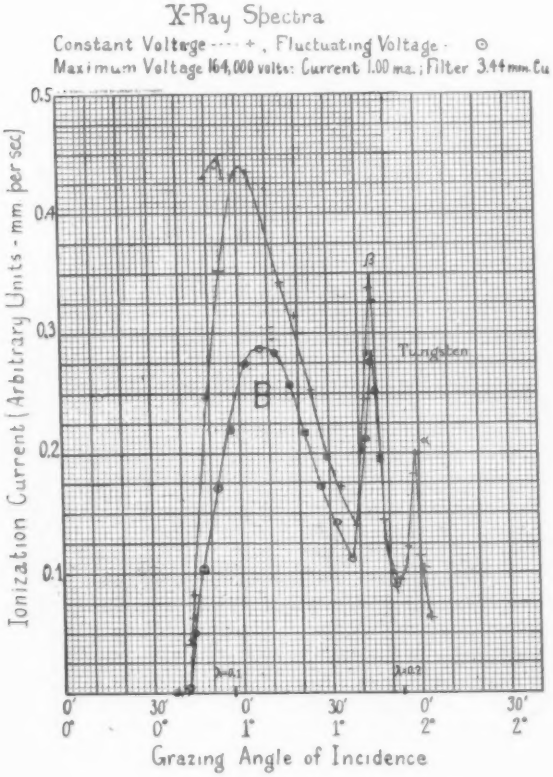
X-Ray Spectra
Constant Voltage ---- +, Fluctuating Voltage - ⊙
Maximum Voltage 164,000 volts: Current 1.00 ma.; Filter 3.44 mm. Cu
Ionization Current (Arbitrary Units - mm per sec.)
Tungsten
Grazing Angle of Incidence

FIG. 5.

that of the short waves. The filter does not change the value of the minimum wave-length. It does, however, reduce the value of the *average*, or what we may call the *effective* wave-length of the beam.

These conclusions have been confirmed since the original publication of the curves by a number of investigators.

5. The next problem was to determine whether or not the *x*-ray spectrum depended much upon the mode of exciting the tube. We have made a large number of experiments with constant voltages applied to the tube and with alternating voltages having the same crest values as the constant voltages. Two of the spectrum curves obtained appear in Figure 5. They show that the intensity of the *x*-radiation is much larger for the constant voltage than for the alternating voltage, and also that there is a perceptible shift in the wave-lengths toward the shorter values. In other words, although the current through the tube, the filtration, the focal distance, and the maximum voltage as determined by a

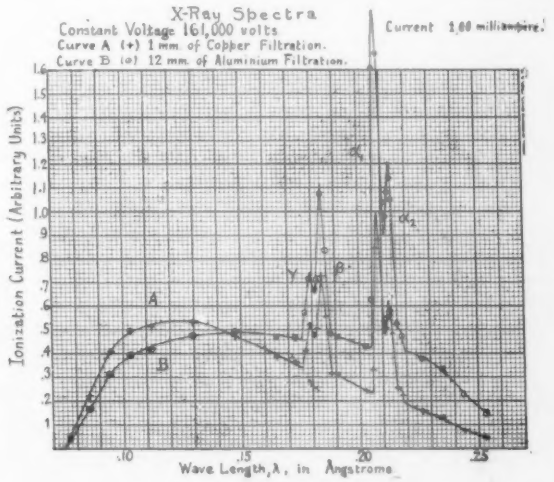
X-Ray Spectra
Constant Voltage 161,000 volts
Curve A (+) 1 mm. of Copper Filtration.
Curve B (o) 12 mm. of Aluminium Filtration.
Current 1.00 milliampere.
Ionization Current (Arbitrary Units)
Wave Length, λ, in Angstroms

FIG. 6.

sphere-gap, remain the same, yet the amount of *x*-radiation and the average wave-length differ from each other in the two cases. These results are important, as indicating that neither the intensity nor the average wave-length of the *x*-ray beam can be determined simply by measuring the current through the tube, the maximum voltage, the focal distance and the filtration.

6. An important problem has been the investigation of the spectrum of *x*-rays that have passed through different kinds of filters. The curves in Figure 6 represent the spectrum of the *x*-rays that have passed through 1 mm. of copper and 12 mm. of aluminum, respectively. It will be seen that in the region of short wave-lengths a larger amount of radiation passed through the 1 mm. of copper than through the 12 mm. of aluminum, whereas in the region of longer wave-lengths, more radiation passed through the 12 mm. of aluminum than through the 1 mm. of copper. From this we

conclude that, if we desire to produce a beam of short wave-lengths, copper is a better substance to use as a filter than aluminum.

The peaks on the curves represent the characteristic radiation of the tungsten target.

Experiments indicate that silver, and some of the rare chemical elements with atomic weights a little larger than silver, would, if used as filters, give somewhat

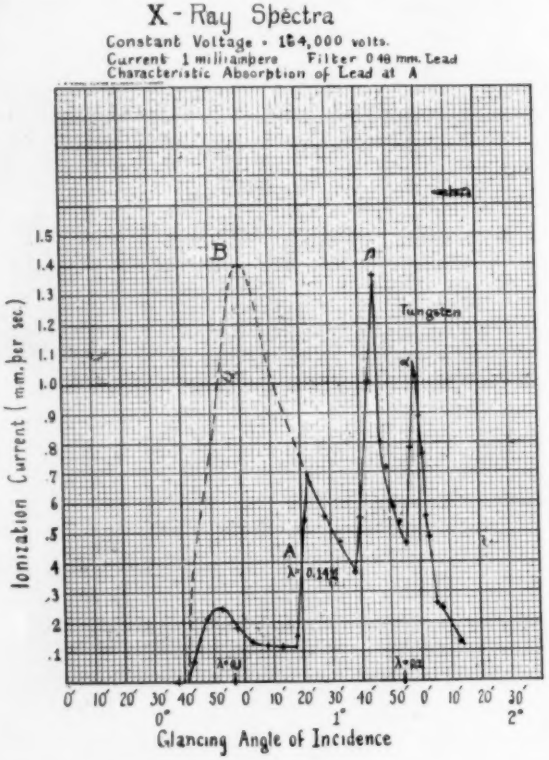

FIG. 7.

better spectra than the copper. The difference between these rare chemical elements of higher atomic weight and copper, however, is so small that the additional expense, etc., incurred would scarcely justify their use as filters.

It might be supposed that chemical elements of still higher atomic weight would, when used as filters, produce still better *x*-ray spectra. This, however, does not appear to be the case. The curve in Figure 7 represents the spectrum of the *x*-rays coming through a thin sheet of lead. It will be seen from the shape of this curve at *A* that the *x*-rays of shorter wave-length than 0.1411 are largely cut off by the lead. If the lead had not this peculiar property of cutting off short *x*-rays, the curve would have taken some such form as that represented by *B*. Since, therefore, the lead cuts off a great deal more of the shorter wave-lengths than of the longer, lead should not be used as a filter. In general, no chemical elements of very high atomic weight should be used as filters, if we desire to produce a beam of rays of short wave-lengths. The exact wave-lengths at which the various chemical elements cut off the shorter rays may be found in published tables.

7. We have been experimenting recently with *x*-ray tubes having targets composed of thorium and of uranium. Uranium is the chemical element of highest atomic weight known, and thorium is the chemical element of next highest atomic weight. At voltages in the neighborhood of 80,000 or 100,000 volts, the uranium and thorium target tubes do not project through a filter of several mm. of aluminum quite as intense a beam of *x*-rays nor of quite so short an effective wave-length as does a tungsten target tube operated under the same conditions. At much higher voltages, however, and with fairly high filtration, the advantage lies on the side of the uranium and thorium tubes. These tubes produce much more intense beams of rays and shorter average wave-lengths than tungsten tubes do. These peculiarities are doubtless due to the fact that 80,000 or 100,000 volts produce the characteristic radiation of the tungsten target, but do not suffice to produce that of either thorium or uranium. It requires nearly 110,000 volts to produce the characteristic radiation of thorium, and nearly 115,000 volts, that of uranium. Further, preliminary estimates of the principal wave-lengths of the characteristic *x*-rays give the values .117, .134 and .139 for thorium, and the values .111, .126 and .131 for uranium. These are very much shorter than the corresponding wave-lengths for tungsten, as indicated by the peaks on the curves of Figure 4. Had a thorium or an uranium target tube been employed in the experiments, the peaks would have come about where the maximum of the copper filtration curve lies.

Such a curve would indicate a much better distribution of energy in the spectrum than that for the tungsten target.

The fact that the radiation at high voltages from uranium and thorium is much more intense and of much shorter average wave-length than that from the tungsten under the same conditions, is an additional indication that, in estimating dosage, we should use some method of measuring the radiation that comes from the tube, rather than trust to measurements of voltage, current, filtration and focal distance.

8. Some eight years ago I was using an ionization chamber and galvanometer to measure the intensity of *x*-ray beams. I gave a brief description of the apparatus at the meeting of this society in 1914. Since then, owing to the improvement in the construction of galvanometers and to the increased intensity of *x*-rays as now used, I have been able to reduce the sizes of the ionization chambers, and make them more convenient. Figure 8 contains a sketch of one of these instruments. The ionization chamber is at *A*. It consists of a number of very thin aluminum plates alternatingly joined together. Hard rubber insulation separates the two sets of plates from each other. Wires running through two flexible insulation cables, *C*, join the ionization chamber with a battery, *B*, and galvanometer, *G*. A flexible metallic shield joined directly to the earth, as indicated in the figure, covers the cables. The ionization chamber, also, is shielded by a very thin sheet of aluminum. This shielding is important for purposes of electrostatic protection. The long, flexible cables allow the ionization chamber to be placed in any desired position in the *x*-ray beam, while the battery and galvanometer lie on a conveniently placed shelf. When the ionization chamber lies in a beam of *x*-ray, the rays make the gas between the sets of plates a conductor of electricity, and a current from the battery flows around the circuit through the galvanometer. This current depends upon the intensity of the *x*-ray beam, and we take the magnitude of the current as a measure of that intensity. We do not have to measure a time interval by means of a stop watch, as in some instruments, but simply read the deflection of the galvanometer, and use it as the indicator of the beam's intensity at the moment.

In order that the measurements of ionization currents by means of a chamber of this kind shall represent accurately the intensity of *x*-ray beams, it is necessary to calibrate the ionization chamber by means of a standard instrument, in which the rays pass through a large volume of

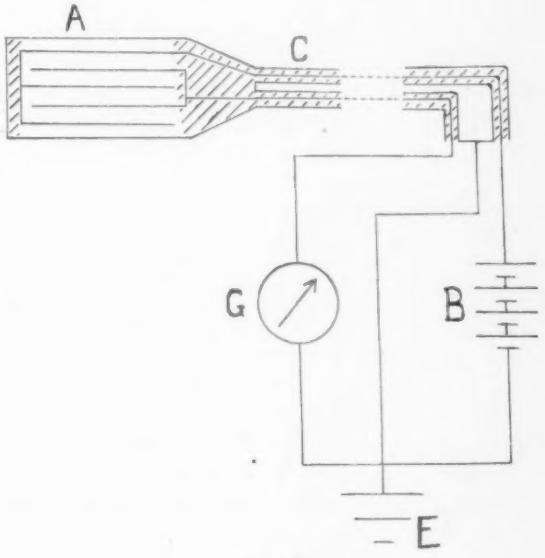

FIG. 8.

air without striking any of the electrodes inside of the chamber. The standard ionization chambers that I was using in 1913 and 1914 had volumes ranging from 500 to 2,000 c.c. The size of the chamber depends upon the precision with which we desire to make the calibration.

To express suitably the intensity of a beam of *x*-rays we must adopt some unit of measurement. I have chosen for our own work to take as the unit of intensity a beam of *x*-rays that would produce an ionization current of one electrostatic unit in each cubic centimeter of air, if the rays did not strike any of the electrodes in the ionization chamber, and if all of the secondary radiation from the molecules of the air were absorbed in the air. This unit we call E. It is a unit of radiation intensity, and not a unit of dosage. To

get the dosage, we must multiply the number of units of intensity that we are using by the length of time of exposure. If the length of the exposure is expressed in seconds, then the product of the intensity expressed in the above units multiplied by the time in seconds equals the dosage, as expressed in the German researches by the letter "e," following Friedrich.

By way of illustration, I shall mention a few intensities of *x*-ray beams under various conditions as expressed in these units. If an ordinary *x*-ray tube is operated at 82,000 volts with 5 ma. passing through the tube and with a filter of 2.6 mm. of aluminum, the intensity of the radiation at a distance of 40 cm. from the tube is about .38 E. If we operate the tube at 200,000 volts with 4 ma. and a filter of ½ mm. of copper, the intensity at 80 cm. from the target amounts to about .21 E.

To get the dosage, we have to multiply the intensity expressed in E by the time of exposure expressed in seconds. The unit of dosage we may call ES, indicating that the intensity is expressed in E and the time in seconds. It seems to me important in estimating and recording dosages to determine and state the magnitudes of both the intensity and the time factors. Although for small changes in the factors it may not make much difference, yet, in general, the effects produced by radiation are not exactly proportional to the product of the two. Exposure to very weak radiation for a long time does not produce the same changes as exposure to very intense radiation for a correspondingly short time.

The ionization chamber, as described, measures the intensity of the *x*-ray beam. In order to get an estimate of the penetration factor, I have adopted the idea of using the *effective* wave-length of the beam. The effective wave-length of the beam may be defined as the wave-length of the monochromatic ray that has the same absorption in a given case as the whole beam itself has. In order to measure the effective wave-length of an *x*-ray beam I use either one of the methods described in the March number of THE AMERICAN JOURNAL OF ROENTGENOLOGY, pages 170 and 171. By means of the ionization chamber I measure the fraction of radiation that gets through a plate of copper or aluminum, and then read off the corresponding wave-length by means of the curve in Figure 9.

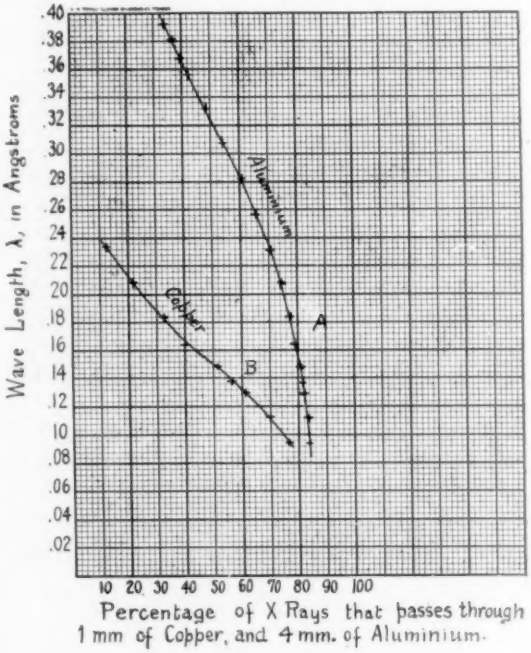

FIG. 9.

In the second method of measuring the effective wave-length, I determined the thickness of aluminum that is equivalent in absorbing power to a given thickness of copper, and read off the wave-length from the curve of Figure 10.

The effective wave-lengths of the beams of rays coming from an *x*-ray tube operated at 80,000 to 100,000 volts and with filters of several millimeters of aluminum usually range from .22 to .28 Ångströms. A constant voltage of 165,000 volts or alternating voltage of 200,000 volts (peak value) produces a beam of *x*-rays having an effective wave-length in the neighborhood of .16 after it has passed through ½ mm. of copper. At about 200,000 volts constant voltage the effective wave-length lies in the neighborhood of .145.

I find, on examining different generating plants, and also the same generating plant under different weather conditions, etc., that there are considerable variations in the intensity and effective wave-lengths of the *x*-ray beams produced, even though the

currents, as measured by the millimeter, and the voltages, as determined by a sphere-gap, are the same.

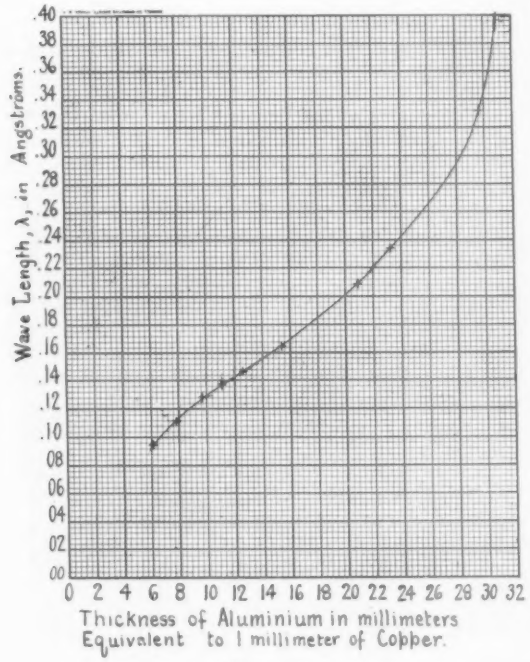

FIG. 10.

Owing to the great advances that have been made in our knowledge of *x*-radiation and to the improvements in physical measurements of *x*-ray beams, it would seem desirable for an association such as the American Roentgen Ray Society, to organize in the various centers of our population intensive courses of lectures on the physics of *x*-radiation.

9. A brief description of the generating plant I have used for producing a constant voltage to be applied to the *x*-ray tube may not be out of place. The fundamental principle of the plant is old. I saw a machine based on this principle in operation in London as early as 1905.

A diagram representing the electrical circuits may be found in THE AMERICAN JOURNAL OF ROENTGENOLOGY, July, 1922. One end of the secondary coil of a transformer, delivering current at a maximum voltage of V volts, is connected to ground; the other end is joined through electrical valves to the two plates of a condenser respectively. One valve lets the positive electricity through, but not the negative. The other valve lets the negative electricity through, but not the positive. Thus the condenser plates become charged to plus V volts and minus V volts respectively, and there is a constant voltage of 2 V volts between them. The *x*-ray tube is joined to the two plates of the condenser, as indicated, and operates, therefore, at twice the maximum voltage generated by the transformer. I have found no better instruments to use as valves for high-voltage work than the new, large Coolidge *x*-ray tubes.

The advantages of using a constant voltage generating plant of this kind are not only that it produces a better *x*-ray spectrum (Fig. 5) but also that it appears to be less hard on the *x*-ray tubes and runs almost noiselessly.

10. It appears to be very fitting in a Caldwell lecture to lay especial stress upon adequate protection for the operators. For the last nine years we have adopted the plan of placing the *x*-ray tube and the generating plant in one room and radiating through the walls or the ceiling into adjoining rooms. Figure 11 is a rough sketch of the arrangement of the rooms in our new building that has just been completed. The generating plant and *x*-ray tubes are in a central room, surrounded by five other rooms which are

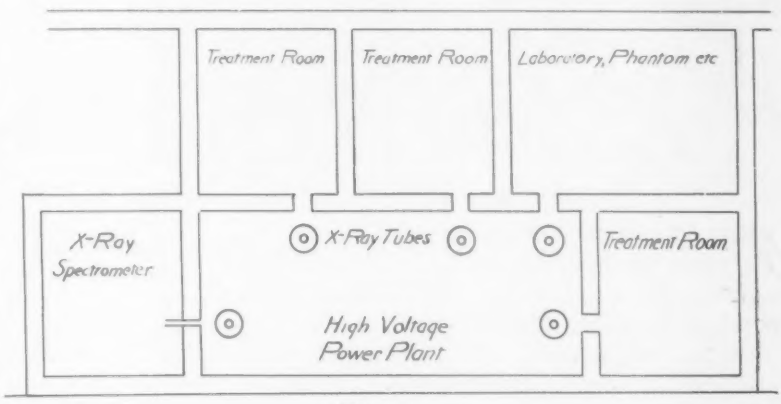

FIG. 11.

used for treatments and for laboratory investigations. The *x*-ray tubes hang opposite holes in the walls and ceilings, through which the rays pass and which contain the various filters, etc. The patients to be treated lie on mattresses on the floors of the rooms above the *x*-ray room, or on a table in the room alongside of the *x*-ray room. With this arrangement, no odor or noise can be perceived in the room where the patient lies. In fact, he does not know whether the *x*-rays are turned on or off. This arrangement apparently reduces the nausea of the patients, although it does not completely eliminate it.

Figure 12 reproduces a photograph of a part of the *x*-ray room itself. The high-tension electrodes can be seen and an *x*-ray tube suspended by silk cords from the ceiling opposite one of the holes.

Figure 13 represents ionization chambers placed in position to measure the intensity and effective wave-length of an *x*-ray beam coming through the hole in the floor. The small one has been described in Figure 8. The larger ionization chamber is one of the standards used to calibrate the smaller chambers. The galvanometer and battery, etc., rest on the shelf in the corner.

Figure 14 is a photograph of the patient's bed in one of the treatment rooms above the *x*-ray room. One section of the bed consists of a wooden framework covered with canvas. This section lies over the hole in the floor through which the beam of *x*-rays comes. The ionization chamber, seen close to it, may be thrust through the small hole and thus placed in the line of the *x*-ray beam to measure its intensity at any time during the treatment. The ionization chamber, also, may be held above the patient to determine how much radiation passes through, or at the sides to measure the secondary radiation, etc.

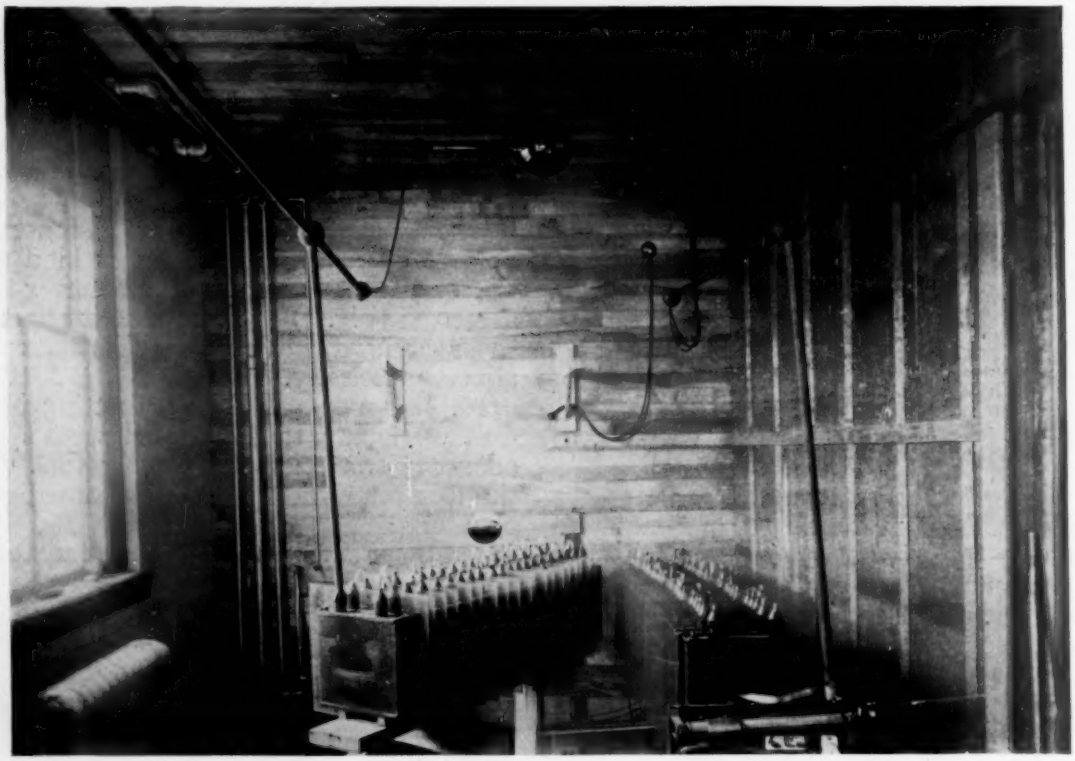

FIG. 12.

11. We have begun an intensive investigation of the biological effects of these *x*-rays of short wave-lengths. So far, the results do not differ essentially from those published in the recent literature on this subject. We have seen very large tumors melt away under the action of the rays. Some of these have been internal tumors,

the sizes of which have been estimated from *x*-ray photographs. Just how permanent the retrogression of the tumors may turn out to be, no one can tell at present, for these penetrating rays have been used for a short time only. There can be no doubt, however, but that the temporary palliative effects in some cases are far superior to those that can be produced in any other way.

The present methods of measuring *x*-ray intensities and wave-lengths have

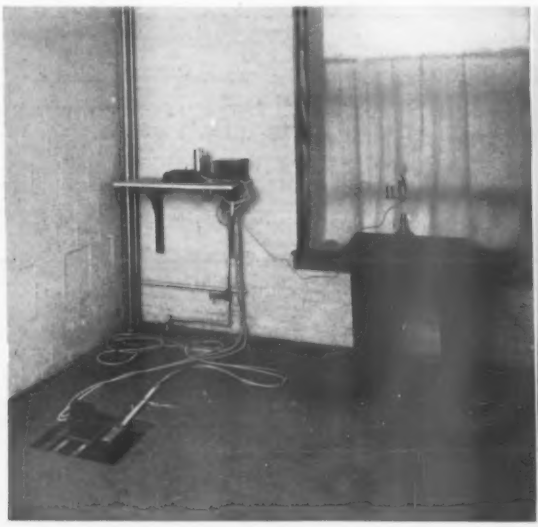

FIG. 13.

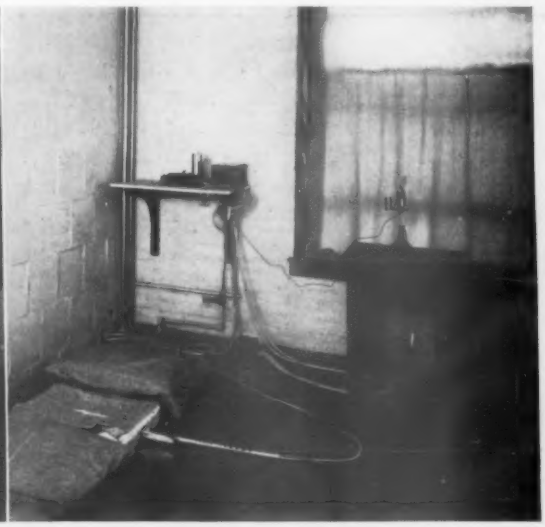

FIG. 14.

At present we are examining, in particular, the blood changes produced by radiation. These changes seem to be somewhat irregular, the most regular being the changes in the white cell count. The clinical findings appear also to be quite irregular. Sometimes the temperature rises, sometimes it falls, and in other cases it remains normal. The same may be said of pulse and respiration. The great irregularity in the effects produced by the rays suggests that either the methods of examination are too uncertain, or else we do not yet understand all of the conditions required to produce the different effects. The irregularities are probably due to a combination of both of these. The subject demands an extensive and profound series of investigations.

far greater accuracy than those employed in the determination of the biological effects produced by the rays. As is well known, the *x*-ray expert today possesses one of the most important and far-reaching methods of diagnosis in existence. Owing to the increase in the accuracy of estimating dosage, he now possesses, also, a method of treating certain types of disease that is not excelled in precision of measurement in any other branch of medicine or surgery.

ON THE FUNCTION OF THE MUSCLES OF THE STOMACH SOME ELECTRICAL EXPERIMENTS*

BY A. E. BARCLAY, M.D.

MANCHESTER, ENGLAND

WE live in an utilitarian age; every new discovery is at once seized upon and turned to practical account. The application of the *x*-rays to the study of the gastrointestinal tract has been no exception to the general rule, and great have been the resulting advances in the diagnosis of abdominal disorders; so much so that a laparotomy ceases to be the usual description of an abdominal operation, and the surgeon now opens the abdomen with a very shrewd idea as to what he is going to find, and what operation he is likely to perform. The efforts of radiologists have naturally been focussed on the pathological subjects, and the radiographic reports are almost always to the effect that the examination is negative—thereby meaning negative from the surgical point of view—or that such and such a pathological condition is present. And yet we all know that in a large number of the cases in which our report is negative, the patient is suffering from definite gastric symptoms. I am not for one moment suggesting that all gastric symptoms emanate from the stomach, for everyone now realizes that the stomach is, more often than not, just the fuse box that responds to faults at any point in the complicated system that deals with digestion, including the nervous system, and the extraordinarily varied psychological factors that act through the mentality of the subject. I do, however, suggest very strongly that we, as radiologists, have focussed our attention on pathology, overlooking the fact that there is such a thing as disordered physiology, which may quite likely account for troubles of very real moment to the welfare of the patient. In other words, I think we have neglected the very foundations on which we should have built our study of pathology. It is true that the study of gastric pathology has become a wonderfully exact science in expert hands. I am certain, however, that it would be of still greater value, and would already have reached a far greater degree of finesse, had we been able to preface our study of pathology by an extensive study of the physiology of that most elusive entity, the normal stomach, an organ so easy to

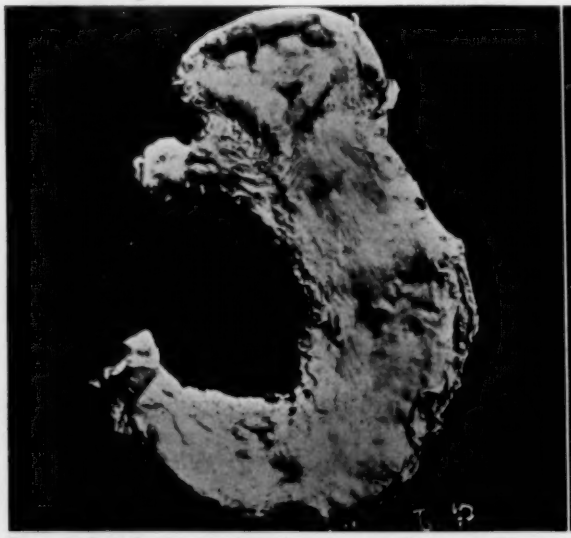

FIG. 1. Peritoneum stripped and the thin, outer longitudinal coat exposed, which is the direct continuation of the longitudinal coat of the esophagus, and is not of great strength.

FIG. 2. A larger view of another dissection.

*Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.

describe in the old days of descriptive anatomy, and so difficult in these days of the study of the living anatomy.

Recently I read a paper on the normal stomach (*Lancet*, July 29, 1922). How simple it seemed before one really tackled the subject in the light of modern physiology! One always realized that the varied appearances of the stomach were largely dependent on variations in tonic action, but one did not realize how difficult it was, and is, to lay real hold of the conception of this function of muscle of which we speak so glibly and know so little. We always think of a muscle as a bundle of fibers which, by contraction, does certain work. Vaguely we realize that muscle has also another function, that of tonic action. Tone, (derived from the Greek τειγω I stretch,) we regard as mechanical tension exerted by muscle fibers, and so it is, to a certain point; but this is only a half-truth, and we must go a great deal further to get at the whole truth. Muscle fibers exert their tonic action irrespective of whether they are stretched or in a state of contraction, namely, whether the stomach is large or small—it is not a contraction, but a *posture* of muscle, the nearest word that Sherrington finds to describe the action. I would strongly recommend to all who are interested in studying the foundations on which we are working, the masterly paper by Sherrington, published in 1915, on Postural Activity of Muscle and Nerve. (*Brain*, xxxviii, part 3, p. 191.)

Our conception of a stomach as hypertonic or atonic is quite likely incorrect. A muscle fiber probably has the same power of tonic action in either state, namely, of attempting to maintain the posture or general contour of the stomach against the various forces that act upon it. To speak of an atonic stomach is therefore incorrect, as such a thing is inconceivable while the muscle fibers are living cells. "Hypotonic" is certainly better, but is still only half way. "Dilated" certainly does not describe the condition, which is rather a "stretched" condition of the muscle than either a dilated or hypotonic organ. The tension inside the hypertonic and the hypotonic stomach may be identical—the tone, as I have said, is a posture of the muscle wall. However, I did not start this paper with the intention of dealing with this very difficult subject,

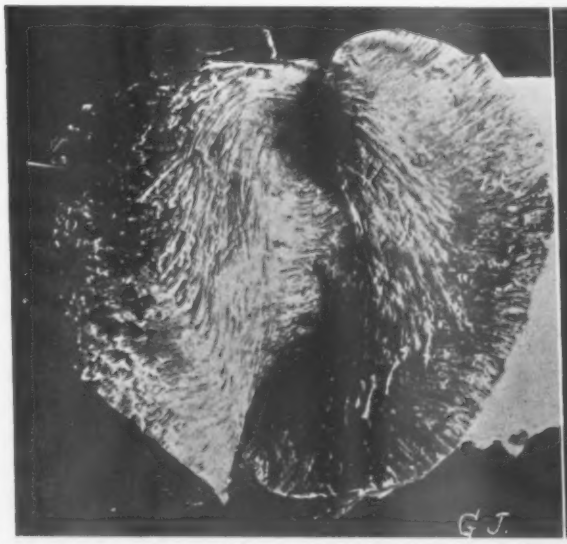

FIG. 3. Stomach opened down the great curvature and mucous membrane dissected off. Note the innermost coat, the oblique band running down either side of the lesser curvature and branching out fanlike, but confined to this portion of the stomach, leaving a narrow gap along the lesser curvation between the two sides. Jefferson has shown that in the upper 2 inches, this band is quite free from the underlying muscle wall, but lower down it spreads out on either side, fanlike, and its fibers intermingle and fuse with the fibers of the circular coat, forming a network in which the actual fibers appear to join each other.

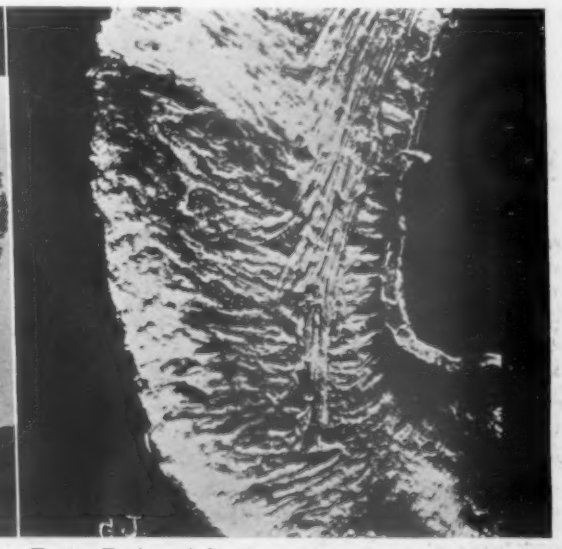

FIG. 4. Fusion of the fibers. Note the tangle of the fibers which form the circular coat.

although I felt a few words were necessary in order to make clear the interpretation of the small experiments to be described.

It is also essential to remind you of the anatomy of the stomach. We have always been taught that there was an outer serous coat, the peritoneum, inside which were three muscular layers bounded internally by the mucous membrane. We realized that the lesser curvature was thicker than the greater because of the greater thickness of the muscular wall. We also knew that there was an outer longitudinal coat, a middle circular and an inner oblique coat, but apart from examination purposes, they meant nothing to us. Forssell, in his book, describes these admirably, and Jefferson has some beautiful dissections shortly

FIG. 5. Gastroptosis.

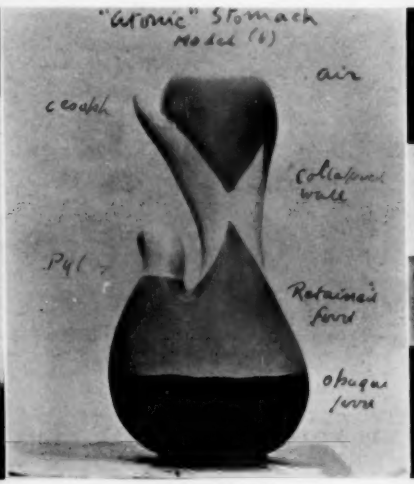

FIG. 6. "Atonic" stomach.

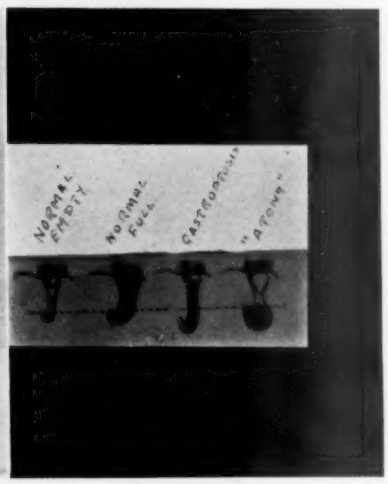

FIG. 7. Variations of the normal.

to be published in the British Journal of Surgery.

We all know the appearance of the so-called atonic stomach (the organ that is stretched by the weight of the food it carries) and the ptosed stomach, which, although it descends low into the pelvis, is still able to maintain its contents in tubular form. Often these two types run into each other, but the pure "atonic" (hypotonic) and ptosed stomachs differ from one another very markedly in one respect, namely, the lesser curvature. In the stretched hypotonic stomach, the lesser curvature is not elongated. It is practically of the same length as in the normal, although the greater curvature is enormously increased. But in gastroptosis the condition is different—the lesser curvature is lengthened considerably and the greater curvature is only increased more or less correspondingly, (together with the anterior and posterior walls, of course). It seems to me that the length of the lesser curvature is the fundamental difference in the two types, both of which are variations of the normal.

There is a type of stomach which I have always called the "cup and spill" type, which has been named in the States the "drain trap" type, in which the upper part of the stomach forms a cup, and the food spills over into a more or less normal lower pyloric portion. Generally the cup is spilling forward, but sometimes it is seen spilling to the inner side, and occasionally to the outer side. Quite frequently the condition is not present on the following day. I have seen all these types of "cup and spill" in stomachs which were giving rise to no symptoms, and I came to the conclusion that they also were, for the most part at any rate, variations of the normal. One day, my partner, Dr. J. M. Morison, was inflating a perfectly normal J-shaped stomach with CO_2, and the result was that as the gas distended the fundus and pressed the diaphragm up, the upper portion of the stomach formed a cup, and the food spilled over to the inner side, giving a typical "cup and spill" stomach. This showed that the condition

could be produced in a perfectly normal organ.

How could this curious appearance be produced? I was already much impressed by the behavior of the lesser curvature, as I have said, and it occurred to me that this exceedingly well-formed band of oblique fibers might give the explanation if we premised that it was capable of action independent of the other muscular coats. It was the only explanation that would meet the case, so far as I could see, and therefore I thought it worth while to attempt to test the reaction of various parts of the stomach wall by electrical methods. By the courtesy of Mr. E. D. Telford, we carried out a series of tests in his operating theater at the Manchester Royal Infirmary on a man in whom we had diagnosed a duodenal ulcer, but who was in good condition otherwise. A rather larger incision than usual was made and the anesthesia was as light as possible as soon as the abdomen had been opened. A large indifferent electrode was placed under the patient's back, and, with an olivary pointed electrode, we applied the stimulus direct to the stomach walls. At first we tried the interrupted galvanic current, but this met with no response—possibly the anesthesia was too deep at this period. We then switched over to an interrupted sinusoidal current, and at once obtained contraction of the stomach wall. Wherever we stimulated on the greater curvature and anterior wall, a band of contraction occurred, a typical incisura, the greater curvature being drawn in towards the lesser curvature in every instance. This appeared to be entirely due to contraction of the circular fibers drawing in the free greater curvature towards the thicker and comparatively fixed lesser curvature, which was what one expected. We then applied our stimulus to the lesser curvature at various points in the lower third, and obtained no contraction of gastric muscle, so far as we could see. There was, however, a very definite tendency to retching and straining; so much so that we thought the patient was coming round. However, on cutting off the current, the spasm at once relaxed, and did not recur when we applied the electrode at other points. The reaction seemed to be a general spasmodic contraction of the diaphragm and abdominal muscles.

FIG. 8. Normal J-shaped stomach.

FIG. 9. "Cup and spill" produced by inflating the stomach with CO_2.

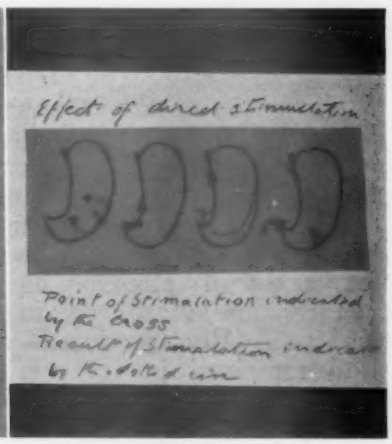

FIG. 10. Effect of direct stimulation.

The liver was then drawn aside and the electrode applied to the lesser curvature in its upper third. The result of this was a very definite response which we obtained with each stimulation: the stomach, which was bulging out of the wound, was drawn up into the abdomen, descending again slowly as soon as the current was cut off. There was apparently no suggestion of the formation of an incisura, and the reaction seemed to be due to a contraction of the oblique band acting entirely by itself.

One other point of stimulation was tried, namely, the peritoneal surface of the duodenal ulcer. There was no local response

whatever, but an incisura appeared in the lower third of the stomach such as would give, on the screen, the hour-glass appearance which we so often see in connection with duodenal ulcers.

The way in which the reaction occurred was interesting. It was not immediate, but took perhaps ten seconds to show itself, attaining its maximum in another ten seconds and relaxing in about fifteen seconds, I should judge. At no period of the experiments did we obtain any contraction that was suggestive of peristaltic action.

These experiments, therefore, go a very long way toward confirming my hypothesis that the oblique band can act entirely independently of the circular and longitudinal coats; and if this is correct, I think we can say that gastroptosis is due to elongation of the oblique band, while hypotonus, or so-called atony, is the relaxation, lengthening and possibly stretching of the fibers of the circular and longitudinal coats, the oblique band retaining its normal length. In the case of the "cup and spill" stomach, one can explain the mechanism most easily in the case that was artificially produced—the oblique band remained in its normal state of posture or tone while the gas distended the fundus, stretching the thin wall above it so that the oblique band held up the lip of the cup. Why some of these "cup and spill" stomachs should empty forwards or to one side or the other is a mechanical problem; when we consider that the fundus of the stomach has ample room for rotation and that the cardiac orifice is the only comparatively fixed spot, I think we can picture the way in which it is formed; particularly so if we take our hypothesis a little further and suggest that the two sides of the oblique band can act independently of each other just as we have separate control of the two sides of the face. This, moreover, has the slight support of the textbooks of anatomy in which it is stated that the nerve supply of the stomach is through the terminal branches of the two pneumogastrics with the addition of various off-sets from the sympathetic: that the left supplies the anterior wall, while the right supplies the posterior wall. If this possible independent action of the two sides of the oblique band is taken into consideration, and also the fact that in the upper 2 in. it is quite free from the underlying muscular coat, I think we can allow the possibility that it is the persistent contraction of this band in the presence of relaxation of the other muscular structures that allows the formation of the varied types of "cup and spill" stomachs which are met with.

I believe that the chief function of the oblique band is to carry the weight of the stomach and its contents, that the functions of the other two coats are concerned with peristalsis and with that ligamentous action of muscle which we call tonic action, but which is better described as posture.

This communication is an attempt to give one small side of a very difficult subject. I am fully alive to the value of the splendid experimental work that Alvarez is doing, and I am sure that his and other work done on the physiology of the alimentary tract is the real hope of further progress in a realm of diagnosis which has almost jumped the study of the physiological elements and yet made a startling success in the elucidation of pathological abdominal conditions.

WHAT IS THE BEST METHOD FOR THE TREATMENT OF UTERINE FIBROMYOMATA BY MEANS OF THE ROENTGEN RAYS?*

BY M. BÉCLÈRE, M.D.

Academy of Medicine

PARIS, FRANCE

Mr. President and my dear Colleagues:

I greatly appreciate the recognition I was so fortunate as to receive from the leading roentgenologists of the United States, and only regret that I am not in a position to thank them personally.

Many of you I know only by name and from your achievements, but I would like to enter into more intimate relations with you, take part in your work, and attend your Congress. Being deprived of this pleasure, I beg you to accept my sincere regrets and to receive this unpretentious essay, which I present to you, my colleagues of the United States, as a token of my admiration, gratitude and friendship.

BÉCLÈRE.

It was in France that the roentgenotherapy of uterine fibromyomata was inaugurated with the appearance of the first essay of Dr. Foveau de Courmelles, of the Academy of Sciences, published in January, 1904. Since then, thousands of observations, made in all countries, have demonstrated the efficacy and harmlessness of this new treatment. The statistics of 700 cases which I reported show that but one per cent of cases was unsuccessfully treated, while in only 9 cases was roentgenotherapy wholly ineffective and obliged to give place to the knife. This shows the efficacy of the new treatment. There remain only two questions which must be discussed, namely; (1) the contraindications to the roentgen rays, and (2) the best method of their employment.

Before the great experience of the radiotherapists and the improvement of their instruments and technique, most of the contraindications which were formerly, and some of which are still, advanced today, against the roentgenotherapy of myomata, have successively disappeared. By reversing the ancient formula, one might say that today roentgenotherapy is contraindicated only in cases in which, for some urgent reason, surgical intervention becomes absolutely necessary.

Now, which is the best method for the employment of the roentgen rays? Should only the ovaries be exposed to irradiation, or the whole myomatous uterus, together with the ovaries? Is it best to give the whole treatment in one or several sittings? This is the technical problem which I propose to elucidate.

Regarding the action of the roentgen rays in the treatment of uterine fibromyomata, two theories prevail at present. One is that held by the majority of the German radiotherapists, the other that of almost all the French radiotherapists. For brevity's sake, we will designate one as the German and the other as the French theory.

The German theory has been stated many times, but never elsewhere as clearly as by Seitz and Wintz. They declare: "In the treatment of uterine myomata, the roentgen rays are only efficacious through their action upon the ovaries. After castration by means of the roentgen rays, the retrogression of the myomata takes place in exactly the same manner as after a surgical castration or after the onset of the natural menopause. The muscular fibers of the myomata are not affected by the same dose as is sufficient to produce castration." In the opinion of these authors, the diminution in the size of the irradiated myomata generally does not begin until four or five months after the treatment. According to other German authors, it takes place sooner and begins after one or two months. But almost all of them hold that it is exclusively due to ovarian activity, and does not manifest itself before the cessation of the menses.

*Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12-16, 1922.

In contradiction to these assertions, unbiased clinical observations have revealed to the majority of French radiotherapists that the reduction in the size of the myomata which have undergone roentgenotherapy is quite often more rapid and momentous than that which follows the natural menopause. It has been shown that this reduction manifests itself before the treatment has brought about the suppression of the menses. As for me, I have only verified the findings of my predecessors. The observation of a large number of cases, the regular weekly sittings, the invariable habit of measuring in centimeters, before each sitting and after the emptying of the bladder, the distance between the upper pole of the uterine tumor and the pubic symphysis, have led me to form the conclusion which, in 1913, at the International Congress of Medicine, at London, I announced, which I formulated in 1919, at Brussels, at the first Congress of French-speaking gynecologists and obstetricians, and which I repeated in 1921, before the Academy of Medicine of Paris: *The reduction in the size of palpable uterine tumors begins with the inauguration of the treatment; in most instances it becomes noticeable at the third, sometimes even after the second sitting. From week to week the upper pole of the uterine tumor approaches more or less rapidly the pubic symphysis; in the most favorable cases it may approach at the rate of about one centimeter in a week.*

This retrogression of the myomata, which constantly precedes for one, two or even three months the suppression of the menses, is, in my opinion, a convincing proof of the direct action of the roentgen rays upon the myomatous tissue. The objection may be raised that the ovarian activity is before its suppression gradually attenuated, that the rapid reduction in the size of the uterine tumor is only due to a diminution of the secretions of the ovaries and the endocrine glands, to a diminished production of hormones of ovarian origin which, through the circulation of the blood, stimulate the growth of the uterine myomata, and that thus the retrogression of the latter is but an indirect result of the irradiations. This objection is easily refuted. It may happen that after the physiological menopause a myomatous uterus continues to grow gradually and slowly, or, several years after the natural menopause, it may, of a sudden, show a more or less rapid increase in size. I have seen several cases of this kind. In women in whom for a considerable period of time the ovaries had been devoid of all activity, as well as in menstruating females, the irradiations resulted in a reduction in the size of the uterine tumor.

This is a convincing proof of the immediate and direct action of the roentgen rays upon the fibromyomata of the uterus, and no further doubt can be entertained in this regard. Moreover, I had the pleasure of learning that some of the German clinicians of the highest repute, such as Wetterer, of Mannheim, and some of the most eminent pathologists, as Haendly, of Berlin, unreservedly admit this direct action upon the myomatous tissue.

According to the French theory, the treatment of uterine myomata by means of the roentgen rays forms a separate chapter in the roentgenotherapy of neoplasms in general, while, according to the Germans, it is but an appendage to ovarian sterilization.

The logical result of the French doctrine, at least as it applies to young females, is the destruction of the myomata without permanent suppression of the menses, and the maintenance and restoration of the possibility of pregnancy. But this ideal can be realized only very exceptionally, and I came across but one authentic observation, published by my friend, Dr. Pfahler, of Philadelphia. In practically all the cases the treatment results in ovarian sterilization, because it is impossible to subject the myomatous uterus to the rays without exposing the ovaries to the rays at the same time. In practically all the cases, the treatment must be carried out systematically until the menstrual function is suppressed definitely, for experience shows that the return of the menses, after a cessation of shorter or longer duration, is always the signal of a recrudescence of the myoma, which was retrogressing, and of a renewed increase in its size, if it has not been completely destroyed by the preceding irradiations. Thus we see that

in practice, the German as well as the French radiotherapists have the same end in view, namely, the suppression of the menses, the former as well as the latter considering the roentgen rays as a sterilizing agency. But, while the German school denies any other rôle to the rays, the French school credits them principally with the capability of destroying the neoplastic cells of which the myomata are made up. This theoretical difference regarding the action of the roentgen rays entails differences as to the technique and method of treatment.

In principle, according to the German school, only the ovaries are the target towards which all the irradiations must be directed. The French school, on the other hand, thinks it is necessary to expose to the rays the whole uterine tumor, whatever its form and size, and not to pay any especial attention to the ovaries, because by raying the entire uterus, however increased in size or more or less deformed, one can be certain that all its adnexa, though more or less displaced, are subjected to the action of the rays. Moreover, in the majority of cases, it is impossible to determine the exact location of the ovaries, which may lie at a greater or less depth under the integument. As a matter of fact, looked at from this point of view, the actual technique employed in Germany is—after many fluctuations—not different from the original technique to which I have always faithfully adhered, for its new features consist in the small number and the large area of the portals of entry of the irradiation.

I was able to ascertain this fact last year, during a visit paid to Professor Seitz in his gynecological clinic, at Frankfort. The irradiation, which, theoretically, aims only at the ovaries and their sterilization, comprises four portals of entry, namely, two for each ovary—one abdominal and the other dorsal. Each of the two abdominal portals of entry has the form of a quadrant, the top of which is limited by the line which joins the iliac spinae, inside by the linea alba, outside and below by the inguinal fold. The two dorsal portals of entry are of the same form, and extend as do the abdominal ones to which they correspond. Thus the whole of the uterine tumor is always irradiated, together with the ovaries, and—as I was able to observe—even in those cases in which the tumor is quite large and its upper pole rises above the line which joins the iliac spines; in order to irradiate it entirely, a third abdominal irradiation field is added to the regular fields.

In other gynecological clinics of Germany they have adopted a different technique, in which the irradiation comprises only two portals of entry, one abdominal and the other dorsal, each one representing a square 14×20 cm.; but the result is the same, as the whole of the uterine tumor is always irradiated, together with the ovaries, a procedure which I have constantly advocated.

Thus, in spite of the difference in their theoretical view, the German and the French radiotherapists agree in regard to the treatment, namely, to irradiate simultaneously the myomatous uterus and the ovaries. It cannot be denied that this procedure is excellent.

Now, having disposed of the first point, let us deal with the second question, —whether it is preferable to give the irradiations in only one or in several sittings.

The ovarian sterilization at one sitting was inaugurated in 1915, at the University of Freiburg, in Breisgau (Baden), as the result of Kroenig's and Friedrich's investigations, to be soon followed by those of Seitz and Wintz, of the University of Erlangen (Bavaria). I shall merely report the conditions under which this method has been made possible: From a physical point of view, the employment of more penetrating and better filtered rays, introduced through larger portals of entry so as to increase the radiation quantity of energy which is absorbed by the ovary as compared with that absorbed by the skin; the employment of an ionization chamber attached to an electroscope, as a measuring device, has made possible the exact estimation of these two quantities. From the biological point of view, the above-mentioned authors have endeavored, on the one hand, to determine the maximum dose which is compatible with the integrity

of the skin—the "erythema dose"—and, on the other hand, the minimum dose which is sufficient, whatever the age of the patient, to destroy the ovarian follicles—the "castration dose." According to Kroenig and Friedrich, the "castration dose" equals one-fifth of the "erythema dose." According to Seitz and Wintz, it is equivalent to a little more than a third; the "erythema dose" of the latter is somewhat less powerful than that of the former. Be that as it may, in Freiburg, Erlangen, Frankfort and quite a few other German universities, under the direction of the professors of gynecology, the ovarian sterilization at a single sitting is practiced and recommended as a simple, rapid method, uniformly applicable in cases of hemorrhagic metropathies and to uterine myomata and to myomata of all sizes, whatever their location, in females of any age; in short, to all clinical cases without any distinction.

The possibility of destroying at a single sitting and in a few hours the menstrual function, and, at the same time, checking all losses of blood, represents, from a technical point of view, remarkable progress. That this method of irradiation offers advantages in certain cases is undeniable, but, on the other hand, we must take into consideration the nature of these advantages and the price paid for them, before we decide whether the treatment of myomata at a single sitting is always the best method.

Taking into consideration the therapeutic results, we must ask the following questions: (1) Is a single castration dose always sufficient? (2) Is it always immediately followed by amenorrhea? (3) Is the menopause thus obtained always permanent? From a study of the articles written on ovarian sterilization at a single sitting we are forced to answer in the negative each of these three questions and to formulate the following propositions:

1. A single castration dose given according to the teachings of Seitz and Wintz is not always sufficient for the production of ovarian sterilization; in a certain number of cases, the percentage of which is by no means negligible, a second irradiation becomes necessary. Regarding the treatment of myomata through castration at a single sitting, it is impossible to affirm that a single irradiation will produce the desired result and that it will not be necessary to repeat it.

2. When a single castration dose is sufficient for producing ovarian sterilization, immediate amenorrhea does not always follow, having been observed in only a small number of cases. Frequently menstrual hemorrhages appeared once, more often twice, and, in certain cases three times before they were suppressed. In this regard, the results do not differ essentially from those obtained by the administration of repeated and smaller doses.

3. The menopause obtained at a single sitting is not always permanent. The return of menstrual hemorrhages, after they have ceased for a longer or shorter period of time, is not of rare occurrence. In these recurrences, as seen among patients treated with the same dose, age is an important factor. Thus Frederic Winter, of the University of Munich, who performs ovarian sterilization at a single sitting with a dose, which, it is true, is smaller than that employed by Seitz and Wintz, has observed no recurrences in women beyond the age of fifty-one, but he has seen recurrences in 10 per cent of cases between forty-one and fifty, and in 30 per cent of cases between thirty-one and forty years of age.

To sum up: viewed from the standpoint of the therapeutic action, in the proper sense of the term, ovarian sterilization at one sitting does not produce results superior to those that, with our improved modern instruments, we obtain today from several sittings. The advantages are, as a matter of fact, not of a medical but of an economic nature. The fact that they have to be absent from home only once, means a considerable saving of time and money for patients who live far away from the city where they are to be treated. The public clinics with a limited number of beds, where congregate a large number of less opulent patients, are interested in keeping these patients in the hospital as short a time as possible. But we must consider the price at which these advantages are bought.

Experienced radiotherapists observed long ago that the suppression of the menstrual function is easier in a woman of forty than in younger females. Nevertheless, Kroenig and Friedrich, and then Seitz and Wintz, from the very first, have maintained that the castration dose is the same for all women, regardless of age. But today, from the most exact examinations, we know beyond the shadow of a doubt that the dose varies, not only with the age as reckoned from the date of birth, but also according to more mysterious factors, by virtue of which a woman of forty-five years of age may appear and really *be* younger than another woman who was born only thirty-five years ago. As a matter of fact, before we have treated a woman, we can never know the exact degree of the "radio-sensibility" of her ovaries.

Sterilization at one sitting requires that every woman coming under treatment receive uniformly the maximum quantity of the "castration dose," which varies within such wide limits that often the minimum, or at most a medium quantity, would be quite sufficient for bringing about a cure.

Moreover, we would attach little importance to the administration of a dose which exceeds that strictly necessary for effecting a cure, if the maximum dose given at one sitting were exempt from causing any untoward effects. But this is not the case. The majority of patients subjected to this treatment experience a more or less pronounced form of indisposition which the Germans designate as "Roentgenkater" and for which I have proposed the designation "mal des irradiations penetrantes" (the penetrating-irradiations sickness).

Moench, of the University of Tuebingen, describes this trouble as follows: In the majority of cases, intense headache; coated tongue; nausea and vomiting; often long-continued anorexia; sometimes articular pains; slight and temporary elevations of temperature. Moench also asserts that in quite a number of his patients he has observed intestinal troubles, diarrhea, colic, meteorism and painful tension of the abdomen; some suffered from such a severe and prolonged diarrhea that they were obliged to interrupt their regular work for two weeks. In most of the articles dealing with the subject of sterilization at one sitting these troubles are passed over in silence, or only briefly mentioned as though they were of no importance. They nevertheless do occur, and to me they seem not to be negligible. I observed their commencement in several of my patients every time I tried to exceed my usual moderate doses, and on the appearance of these troubles I always desisted from my attempts.

If we compare the employment of the maximum dose at one sitting with that of smaller doses given in weekly sittings, we see the great advantage of the latter in not producing any functional troubles, or only those of such slight degree that the patients are not obliged to alter their mode of living, or to give up their usual work. An additional advantage in the weekly sittings is in the fact that their employment does not produce any inflammatory reaction of the integument of women whose skin, like their ovaries, presents a variable "radio-sensibility." On the appearance of the slightest redness or itching, all that is necessary is to postpone the intended sitting for at least a week.

The chief advantage of the method consists in the direct action of the weekly irradiations upon the myomata—if we admit at all that this is the principal object of the treatment. Since the diminution in the size of the irradiated myomata shows itself at the beginning of the treatment and becomes more manifest from week to week, the retrogression undoubtedly commences with the most superficially situated neoplastic elements, which are bound to receive the most powerful dose. Thanks to the method of weekly sittings, each new irradiation—even if the portals of entry for the irradiations are not modified—will never encounter the same zones nor the same thickness of the myomatous tissue. Thus these repeated sittings offer a better assurance of the progressive destruction of the neoplastic tissues than we could expect from a single sitting. We also can feel more certain of the total destruction of the ovarian follicles, the "radio-sensibility" of which varies according to the different stages of their evolution.

The method of weekly sittings presents still other advantages. It enables the radiotherapist, during the entire course of treatment, from its beginning to the incipience of the menopause, whether preceded by one, two or even three appearances of the menses, to make repeated examinations, and to devote his constant attention to the patients entrusted to his care. He can advise them as to the rest they need, or administer the injections and remedies appropriate to their condition. To those who are alarmed by the slightest untoward incident, or the slightest disturbing malaise, he gives reassuring explanations and comforting advice. This psychic and moral part of the task is by no means the least important.

Thus the treatment may be continued till the suppression of the menses and the appearance of the hot flushes, or also beyond this stage, when the patient's age causes the apprehension of the possibility of a recurrence, or if the condition of the myoma makes the prolongation of the treatment advisable.

The task of the radiotherapist is even not ended with the supposedly last irradiation. He has to reckon with the possibility of a reawakening of the ovarian function which is heralded by the premature disappearance of the hot flushes, suggesting the possibility of a renewal growth of the myomata. He also should take into account, even after the permanent suppression of the menses, the occurrence of metrorrhagias which, though always slight, call, just as does the renewed growth of the myomata, for a resumption of the irradiations. It is, therefore, of importance that the radiotherapist impart to his patients suitable information and keep them under his observation for a certain period of time.

Each sitting, according to the size of the tumor, requires usually ten minutes, or, in rare instances, twenty minutes. The total duration of the irradiations sometimes does not exceed one and a half hours, most frequently it varies between two and three hours, and in exceptional cases it may exceed four hours. Attention must be called to the fact that these indications refer to patients treated with the old-fashioned instruments and with only a moderately penetrating irradiation, corresponding to a spark which is equivalent to 23 cm. With a modern equivalent the total duration of the irradiation is certainly shortened. Thus the treatment with small doses given in short intervals yields the same therapeutic results as the "one-sitting" method of sterilization, if the former is not superior to the latter, and I believe it is, taking into consideration the retrogression of the myomata and the prevention of recurrences. Moreover, the desired end is attained without exceeding the sufficient dose, which is often quite small, and does not expose the patients to the disagreeable "irradiation malaise." In other regards the method may still be improved.

In conclusion I want to state that each of these two methods has its advantages and its drawbacks and that each fits different requirements.

The choice of the one-sitting method is most frequently influenced by reasons other than medical, namely, the consideration of saving time and money. It is not chosen for a truly medical reason, as, for instance, in cases of extreme anemia where the prevention of a new loss of blood is of the utmost importance; in fact, in cases of this kind one can never be certain of obtaining an immediate amenorrhea. For the large majority of cases of uterine fibromyomata I would prefer the treatment with small doses given at short intervals.

In my opinion, this conclusion may be generalized and applied to all departments of the vast domain of roentgenotherapy. The judicious employment of a pliable method which can be adapted to the exigencies of each particular case is always preferable to the blind acceptance of a uniform formula; but after all, we must insist that the radiotherapist be not only an able technician, but also an excellent clinician.

PROTECTION IN RADIOLOGY*

BY GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

IT is always an honor to be chosen as leader by one's colleagues. This honor is greater when each of the members is a leader in his own community, and many are world-wide known and distinguished, and many have national or international reputations. This honor is augmented by the record of the distinguished presidents who have preceded me. I was surprised when I received the announcement, and have been overwhelmed by the feeling of gratitude, by the sense of unworthiness, and by the weight of responsibility, which always goes with such great honors. There are others among us who are more deserving, but for some reason you have decided to hold them in reserve for future service. I can, therefore, only express to you my thanks. Fortunately, all the officers and committees have been most loyal, and have performed their duties in a manner that will reflect credit, not only upon themselves, but upon the society. The program committee has arranged a series of scientific papers by men, each one of whom is recognized as an authority upon the subject of his discussion; and no radiologist can afford to miss these papers.

There have been too many martyrs to the science of radiology. The loss of each one of these has produced a gap in the rank of leaders, and has delayed progress. There are still among us many who are being damaged physically, and who are being interfered with financially. It has seemed to me, therefore, that "Protection in Radiology" would be one of the most important subjects for our consideration.

PHYSICAL PROTECTION TO THE RADIOLOGIST

The radiologists who began work in the early days of roentgenology were practically all more or less damaged by the radiation. Nearly all have suffered more or less, from some skin degeneration. Some have practically recovered; some are still suffering from these effects; and others have given their lives as a result of earnest enthusiasm, in developing this new science. We have gradually developed means of protection against such radiation as has been used in the past. This does not mean that these past radiations have been modified, or made more safe, but it means, distinctly, that knowledge is at hand, which if used, affords protection to both radiologist and patient.

Radiations have, however, become more and more powerful, and more and more damaging in their effects; and unless proper protection is provided, more serious results will follow than have ever been recorded. This is especially true since the gamma rays of radium and the high voltage roentgen rays have come into the field. These rays produce their effects without noise, without sensation, and without visualization. They act constantly and insidiously, and unless they are guarded against, harmful results will follow. Because the roentgen rays have been more than doubled in their power within the recent years, their dangers are also more than doubled. It is therefore, clearly our duty to provide every protection possible, to be over-cautious, and to use more protection than is actually necessary, rather than repeat the experiences of the past. The early radiologist suffered, not only because there was no recognizable need of protection, but also because there was not even a rudimentary knowledge of the means of protection.

Radium and the roentgen rays are so closely associated in practice, that it is impossible to consider one without the other, even though we are meeting for the special consideration of radium and its usage. During the past year I have been trying to collect data from about 1,500 radiologists throughout the country, with

* Presidential Address. Read at the Seventh Annual Meeting of THE AMERICAN RADIUM SOCIETY, St. Louis, Mo., May 22–23, 1922.

NOTE.—The attention of the reader is called to Dr. Pfahler's article in the October JOURNAL, containing a questionnaire which was widely circulated among workers in radiology.

the object of eliminating unnecessary dangers, and providing more efficient protection for our operators. The replies are gradually being accumulated, but they have not all been returned, and I have not yet had the time to make the proper analysis. I can, however, say that those who are working with radium and with the more deeply penetrating rays are receiving more radiation on their bodies than are the others; which would indicate in a general way that this group of workers must find added protection. We have demonstrated that these rays will pass through ¼ in. of lead at 18 in. distance from the target.

The most definite step toward organized protection in radiology has been the appointment of the *X*-Ray and Radium Protection Committee in England. This committee, up to the present time, has made two reports.* There was also appointed a "Safety Committee," by the American Roentgen Ray Society, at its annual meeting at Minneapolis, September, 1920. The late Professor John S. Shearer, Cornell University, Ithaca, N. Y., was chairman. His loss will be felt by many to whom he was a personal friend, but his death leaves a gap in radiology which cannot be filled, and the work of this important committee will be delayed. No matter what the authority of the committee, iron-clad rules cannot be laid down. The principles of protection must be given, and general guides or suggestions established, but the individual institution and the individual workers must make their application according to the circumstances, in each instance. The number of working hours to be permitted, and the duration and time of vacation must be determined by the actual amount of work done, and the amount of actual exposure to the radiation. In some laboratories, more strenuous work and more actual exposure is obtained in five hours than in other laboratories where the work is only casual and less strenuous, even though ten hours are passed in the laboratory.

* 1. Preliminary Report of the *X*-Ray and Radium Protection Committee. *Arch. Radiol. & Electroth.*, June, 1921. 2. *X*-ray and Radium Protection Committee. Chairman, Sir Humphrey Rolleston, Care of Royal Society of Medicine, Wimpole Street, London.

The following general recommendations have been made by the Protection Committee of England.

GENERAL RECOMMENDATIONS

It is the duty of those in charge of *x*-ray and radium departments to ensure efficient protection and suitable working conditions for the personnel.

The following precautions are recommended:

1. Not more than seven working hours a day.
2. Sundays and two half-days off duty each week, to be spent as much as possible out of doors.
3. An annual holiday of one month of two separate fortnights.

Sisters and nurses, employed as whole-time workers in *x*-ray and radium departments, should not be called upon for any other hospital service.

PROTECTIVE MEASURES

It cannot be insisted upon too strongly that a primary precaution in all *x*-ray work is to surround the *x*-ray bulb itself as completely as possible with adequate protective material, except for an aperture as small as possible for the work in hand.

The protective measures recommended are dealt with under the following sections:

I. *X*-Rays for diagnostic purposes.
II. *X*-Rays for superficial therapy.
III. *X*-Rays for deep therapy.
IV. *X*-Rays for industrial and research purposes.
V. Electrical precautions in *X*-Ray Departments.
VI. Ventilation of *X*-Ray Departments.
VII. Radium therapy.

It must be clearly understood that the protective measures recommended for these various purposes are not necessarily interchangeable; for instance, to use for deep therapy the protection intended for superficial therapy would probably subject the worker to serious injury.

I. *X*-RAYS FOR DIAGNOSTIC PURPOSES

1. SCREEN EXAMINATION

(*a*) The *X*-ray bulb so to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead. The material of the diaphragm to be equivalent to not less than 2 mm. of lead.

(*b*) The fluorescent screen to be fitted with lead glass equivalent to not less than 1 mm. of lead, and to be large enough to cover the area irradiated when the diaphragm is opened to its widest. (Practical difficulties militate at present against the recommendation of a greater degree of protection.)

(*c*) A travelling protective screen, of material equivalent to not less than 2 mm. of lead, should be employed between the operator and the *x*-ray box.

(*d*) Protective gloves to be of lead rubber (or the like) equivalent to not less than ½ mm. of lead, and to be lined with leather or other suitable material. (As practical difficulties militate at present against the recommendation of a greater degree of protection, all manipulations during screen examination should be reduced to a minimum.)

(*e*) A minimum output of radiation should be used with the bulb as far from the screen as is consistent with the efficiency of the work in hand. Screen work to be as expeditious as possible.

2. RADIOGRAPHIC EXAMINATION ("overhead" equipment)

(*a*) The *x*-ray to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead.

(*b*) The operator to stand behind a protective screen of material equivalent to not less than 2 mm. of lead.

II. *X*-RAYS FOR SUPERFICIAL THERAPY

It is difficult to define the line of demarcation between superficial and deep therapy.

For this reason it is recommended that, in the reorganization of existing, or the equipment of new, *x*-ray departments, small cubicles should not be adopted, but that the precautionary measures suggested for deep therapy should be followed.

The definition of superficial therapy is considered to cover sets of apparatus giving a maximum of 100,000 volts (15 cm. spark gap between points; 5 cm. spark gap between spheres of diameter).

CUBICLE SYSTEM

Where the cubicle system is already in existence it is recommended that:

(*a*) The cubicle should be well lighted and ventilated, preferably provided with an exhaust electric fan in an outside wall or ventilation shaft. The controls of the *x*-ray apparatus to be outside the cubicle.

(*b*) The walls of the cubicle to be of material equivalent to not less than 2 mm. of lead. Windows to be of lead glass of equivalent thickness.

(*c*) The *x*-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 2 mm. of lead.

III. *X*-RAYS FOR DEEP THERAPY

This section refers to sets of apparatus giving voltages above 100,000.

(*a*) Small cubicles are not recommended.

(*b*) A large, lofty, well ventilated and lighted room to be provided.

(*c*) The *x*-ray bulb to be enclosed as completely as possible with protective material equivalent to not less than 3 mm. of lead.

(*d*) A separate enclosure to be provided for the operator, situated as far as possible from the *x*-ray bulb. All controls to be within this enclosure, the walls and windows of which to be of material equivalent to not less than 3 mm. of lead.

IV. *X*-RAYS FOR INDUSTRIAL AND RESEARCH PURPOSES

The preceding recommendations for voltages above and below 100,000 will probably apply to the majority of conditions under which *x*-rays are used for industrial and research purposes.

V. ELECTRICAL PRECAUTIONS IN *X*-RAY DEPARTMENTS

The following recommendations are made:

(*a*) Wooden, cork, or rubber floors should be provided; existing concrete floors should be covered with one of the above materials.

(*b*) Stout metal tubes or rods should, wherever possible, be used instead of wires for conductors. Thickly insulated wire is preferable to bare wire. Slack or looped wires are to be avoided.

(*c*) All metal parts of the apparatus and room to be efficiently earthed.

(*d*) All main and supply switches should be very distinctly indicated. Wherever possible, double-pole switches should be used in preference to single-pole. Fuses no heavier than necessary for the purpose in hand should be used. Unemployed leads to the high tension generator should not be permitted.

VI. VENTILATION OF *X*-RAY DEPARTMENTS

(*a*) It is strongly recommended that the *x*-ray department should not be below the ground level.

(*b*) The importance of adequate ventilation in both operating and dark rooms is supreme. Artificial ventilation is recommended in most cases. With very high potentials coronal discharges are difficult to avoid, and these produce ozone and nitrous fumes, both of which are prejudicial to the operator. Dark rooms should be capable of being readily opened up to sunshine and fresh air when not in use. The walls and ceilings of dark rooms are best painted some more cheerful hue than black.

VII. RADIUM THERAPY

The following protective measures are recommended for the handling of quantities of radium up to one gram:

(*a*) In order to avoid injury to the fingers, the radium, whether in the form of applicators of radium salt, or in the form of emanation tubes, should always be manipulated with forceps or similar instruments, and it should be carried from place to place in long-handled boxes lined on all sides with 1 cm. of lead.

(*b*) In order to avoid the penetrating rays of radium all manipulations should be carried out as rapidly as possible, and the operator should not remain in the vicinity of radium for longer than is necessary.

The radium when not in use should be stored in an enclosure, the wall thickness of which should be equivalent to not less than 8 cm. of lead.

(*c*) The handling of emanation should, as far as possible, be carried out during its relatively inactive state. In manipulations where emanation is likely to come into direct contact with the fingers, thin rubber gloves should be worn. The escape of emanation should be very carefully guarded against and the room in which it is prepared should be provided with an exhaust electric fan.

With the object of increasing progress toward the protection of radiologists, I would recommend that the American Radium Society appoint a committee, known as the Committee for Protection in Radiology, which can with advantage cooperate with the Safety Committee appointed by the American Roentgen Ray Society; and together they may be able to formulate certain problems which can be worked out by the Bureau of Standards at Washington, D. C. The Bureau of Standards has already rendered us a great and indispensable service, by making definite measurements of the radium specimens which we purchase, thereby providing a standard product with which to work.

It would seem to me that protective devices could be standardized in the same manner, by the same bureau. The opaque

rubber, rubber gloves, rubber aprons, and rubber protective material used to cover patients should be standardized, and we should know the equivalent value of lead in protective power. The insulating value of this same rubber material could also be examined by the Bureau of Standards, realizing, of course, that this insulating value will change with the deterioration of age. The lead glass used for protection could be tested as to its protective value and its insulating value. Each particular specimen would not need to be tested, but instead, the product as supplied from the manufacturer could be tested from time to time, and a requirement made that the specifications be complied with.

It should likewise be possible to obtain the services of this same Bureau of Standards to send a representative to the various laboratories, especially those engaged in deep therapy, to measure and calibrate the output of the various machines. It should be practical to calibrate each type of machine in a factory and not necessarily calibrate each duplication. Either the same officer or an equivalent officer should be able to pass judgment and make recommendations with regard to the electrical equipment and its safety, both to the operator and the patient.

PROTECTION TO THE PATIENT

1. This form of protection is provided for by preventing any possible escape of electricity to the patient with the use of the roentgen rays. When using the deep therapy machines, it would seem desirable to have them so equipped that the patient would be able to touch any part of the outfit without obtaining any shock or current. This can be provided for by having a grounded screen or grounded encasement between the electrical conductors and the patient.

2. The patient must be protected against any stray or unintentional radiation.

3. Some safety device or arrangement should be provided, so that at no time can the filters be omitted or a lesser quantity of filtration used than is intended. Other forms of protection to the patient, as far as injury or discomfort is concerned, will vary according to the clinical conditions and the treatment necessary.

PROTECTION AGAINST LOSS OF RADIUM

This subject has become a serious one during the past year, because of the frequent loss of radium, usually as the result of some one's carelessness. This has caused the rates of insurance, as furnished by Lloyd's in London, to rise from 2 to 5 per cent. This unjustly penalizes the careful radiologists, who are compelled to bear the expense of those who are careless or indifferent, because they are carrying full insurance.

With the thought of forming a mutual protective organization, consisting especially of the members of the American Radium Society, or others who are careful and responsible, inquiries were sent to the members by your president. This idea received an enthusiastic response from nearly all. A few, however, stated that they were unwilling to enter any mutual insurance company, and especially one managed by physicians. I therefore, enlisted the cooperation of the radium producers, and we are indebted to them, in great part, for the results which have been accomplished. I would especially mention The United States Radium Corporation of New York, The Colorado Radium Chemical Company, and the Pittsburgh Radium Chemical Company. Nearly all the radium owners have expressed the willingness to bear part of their own risk. This had been my recommendation because I believe it would tend to eliminate carelessness; for when the owner is willing to take at least one-fourth of the total risk, in the case of loss of radium, he will at no time avoid taking proper steps and practical precautions, and I believe the losses under such management will be very small. As a result of our efforts we have been able to obtain from the Insurance Company of North America, a policy, which, I believe, is the best yet offered to the society. This, briefly, consists in furnishing insurance at 2 per cent, providing the owner will bear 25 per cent of any particular loss. I have had this policy reviewed by eminent authority and we believe that it contains

no flaws and is fair in every respect. Since the above announcement, the Pennsylvania Fire Insurance Company have announced a similar policy with same conditions. By this process of insurance all objectionable clauses should be eliminated and I am sure that the owner can well afford to take his risk for the money saved.

LEGAL PROTECTION

There is no branch of medicine in which protection of this character is needed more than in the field of radiology. The science is comparatively new, and enthusiastic recruits have entered the field. Many of the effects are mysterious in their character, that is, the rays produce no immediate effect, and there is no sensation. Frequently the patient sees nothing and hears nothing; and because of the mystery to the layman, and frequently because of the mystery to the general practitioner, any symptom or unusual development that occurs to a patient who is under treatment is apt to be ascribed to the treatment, or its effects. It should be borne in mind that all the ailments of the human body which can occur independently of radiation treatment or examination, may also occur conjointly in connection with such treatment. This basic fact is forgotten too often. If every radiologist in the country will do his part toward helping to educate the general public to the idea that other causes should be searched for in a case of unusual symptoms, there will be less annoyance by complaints, and patients will get relief from symptoms which are at present not relieved by the mere explanation, "They are due to the rays."

Protection against unjust claims on account of these developments should be provided for by every radiologist, in making use of the insurance companies organized for this purpose; but best of all, every radiologist should keep in close touch with his colleagues in his county medical society and depend more upon them for loyal support than upon anything else. The loyal support from our colleagues is of more value than the monetary and legal support furnished by insurance companies. Of equal value is the protection provided by membership and association in the organized radiological body. This is useful in establishing educational standards, which act automatically in teaching the various members what is expected of them and what is expected for their patients. Association with colleagues in these societies enables one at least to become acquainted with others and develop personal confidence and respect, and will enable each and every one to assume that proper procedures have been followed, until there is definite proof to the contrary.

Unfortunately, if many accidents occur, the time will come when the insurance companies will refuse to issue policies to those engaged in radiology. At present there is no means of separating the inexperienced and careless from the experienced and careful ones. No standard of requirements is today in existence. To meet these conditions, and to raise the general standard of radiology, for the protection of our specialty against ill reputation, and to protect the general public, I recommend the appointment of a committee to consider the advisability of the formation of a National Examining Board for radiologists for the purpose of examining applicants to determine their efficiency, and to issue certificates in roentgen diagnosis, roentgenotherapy, and radium therapy to physicians, and certificates to technicians who are to work under the direction of physicians.

In conclusion, therefore, I would recommend (1) that the principles of radiology be thoroughly mastered, so that they can be adapted to the individual establishment, for the protection of both the operator and the patient.

(2) That a committee of this society be appointed to cooperate with other similar bodies of national organization, to study and formulate definite directions and rules of protection.

(3) That these committees cooperate so far as possible with the Bureau of Standrads at Washington, in order to secure definite and permanent products, and possibly definite calibration of our outfits.

(4) I would recommend that radium be insured against loss, so that men will not

be suddenly hampered financially and be prevented from carrying on the good work which has been started.

(5) I would recommend that every radiologist be provided with legal protection, with protection from insurance companies and the protection and cooperation of his county medical society.

(6) That every radiologist in the country associate himself with the American Radium Society, both for his and our good.

THE TREATMENT OF CANCER OF THE PELVIC ORGANS WITH MODERATE IRRADIATION*

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IN our paper of last year, presented before the American Medical Association, (*J. Am. M. Assn.*, 1921, lxxvii, 613) we dwelt comprehensively upon every phase of our experience in irradiation therapeutics of carcinoma of the pelvic organs. The further results of this treatment which we now report are but an extension of that series, which then comprised 313 cases, but has now reached 412, leaving a sufficient number of survivors who have passed over the five-year period to give us an approximate estimate as to what we may anticipate from the application of the smaller quantities of radium, (100 mgm.) which we have routinely employed. Set forth on a percentage basis, we may state in the following sentence what our records reveal. Of the patients treated over four years ago for inoperable carcinoma of the pelvic organs, there are 163 dead, 45 living, and 7 not traced, giving a percentage of 20.9 living; of those treated over five years ago, there are 125 dead, 4 not traced, and 31 living: a percentage of 19 plus still surviving and free from manifest evidences of the disease. However, one should qualify these figures by the statement that a five-year period does not necessarily place the patient within a zone of absolute safety, for a very small percentage of those now living may still succumb; but this observation has been identical with our surgical experience. With irradiation, just as with surgery, cancer of the cervix yields the poorest results, and our percentage, as we now estimate it, of this class of cases which are now approaching, or are beyond the quinquennial limit, will be approximately 16 to 18. We venture the hope, however, that our present method of treatment, which has fully been described in our previous paper, may yield a better ratio of cures. Upon this point, however, we venture no positive assertion, for this whole question has been quite too freely dealt with in high percentages of fanciful hopes on one hand, or crass pessimism on the other.

It is, however, a very great satisfaction to realize that of our 412 patients, the vast majority of whom were in the advanced stages of this disease, quite beyond the possibilities of surgical intervention, a large number have had their symptoms mitigated, or completely held in abeyance for a time; the frightful hemorrhages have been stayed for variable periods, and frequently absolutely stopped. In a lesser percentage, pain, when present at the time of treatment, has been actually relieved. This temporary relief of symptoms has been a splendid and an inestimable boon to many of these wretched individuals, even though the checking of the growth may have been but temporary. However, transcending this beneficent value of the remedy in the partial relief of symptoms, stands the incontrovertible fact that a larger number have actually been cured as reckoned on a five-year basis than we had forecasted. In the earlier years of our experience, we dwelt only upon the palliative aspects of this treatment, but last year our report proved that a sufficient number of patients were well after five years

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to make it an assured fact that even among the inoperable patients occasional cures may be effected. At that time, we hazarded the assertion that cancer of the cervix might finally be transferred from the surgical clinic to this new field of therapeutic endeavor. As yet, however, we are not in a position to clinch this tentative forecast by unassailable statistics, and for this reason we do not advise the abandonment of a modified radical hysterectomy in cancer of the cervix in the clearly operable cases, if the surgeon is really skilled in this very difficult and hazardous operation. Surgery certainly maintains its place, for it has justified its position as a life-saving measure in the hands of the thoroughly trained devotee, by saving a large number of cases in the clearly operable type. Yet, after all that has been done to warn the laity of the dangers of cancer and the necessity for early intervention, the number of those to whom surgery can offer no hope is tragically large. It is to this class that we have devoted our attention.

Our list of cases of cancer of the pelvic organs comprises the following: Cancer of the Cervix, 291; Cancer of the Fundus, 41; Chorio-epithelioma of the vagina and uterus, 4; Cancer of the Cervical Stump, 11; Recurrent Cancer of the Vagina after hysterectomy, 22; Cancer of the Vagina (primary), 29; Cancer of the Urethra, 8; and Cancer of the Bladder, 6. In this list cancer of the cervix overshadows by far the combined aggregate of all other types of cancer of the pelvic organs which we have treated, and, as considered individually, shows the worst results so far as our experience goes. The cases of cancer of the fundus were, with possibly three or four exceptions, all inoperable, as judged clinically, and yet they demonstrate, in comparison with cancer of the cervix, that same favorable difference as exhibited in the surgical results in the same localities. While we always follow our rule in cancer of the cervix to withhold operation and to advise irradiation if the growth is of questionable operability, we still urgently maintain that in the same questionable situation, cancer of the fundus unqualifiedly demands a hysterectomy, unless there is some grave systemic contraindication to this procedure. There is ample ground for surgical optimism in advanced cases of carcinoma of the fundus, and we, therefore, hold fast to this assured method of attack. Were it possible to attain comparable results in cancer of the cervix by even a very radical hysterectomy, we could be classed as ultra-conservative so far as this newer treatment is concerned; but only the surgical enthusiast, who possibly scans his one-year results more fully than the small train of survivors who pass over the five-year line, can maintain his optimism when he compares the vast outlay of surgical energy expended with the paucity of results, even in a discriminately chosen series of cases. Of the various organs invaded by malignant growths there are but few that show worse results from operations than the cervix, or better than the fundus. We emphasize this point before this representative body of radiologists, for this class of specialists, of all others, should always keep in the foreground the excellent salvage which surgery has yielded in properly selected cases of cancer in all parts of the body. These two plans of treatment, therefore, must not be brought into conflict if the therapeutic effects of irradiation are to find worthy credence in our fight against cancer. With all available plans of treatment that we now have, we are but marking time, or, as it were, at best have "dug in," in our fight against cancer; for, up to the present, the most enthusiastic radiologist may not justifiably claim any startling advantage over surgery, except in limited localities. A big advance in the treatment of cancer, therefore, must come through some absolutely new method of attack, which is as yet undiscovered. As matters now stand, however, irradiation has unqualifiedly won its right to a place along with surgical means, for it has stepped into the inoperable breach with hopeful assurance of a large alleviation of suffering and a minimum probability of cure.

In the following tables we have recorded our results as verified by a careful follow-up system, which comprises all cases treated up to May, 1922:

TABLE I

CANCER OF PELVIC ORGANS TREATED BY IRRADIATION

	Living	*Dead*	*Not Traced*
Carcinoma of cervix	56	217	18
Carcinoma of fundus	21	17	3
Chorio-epithelioma of vagina and uterus	4	..	..
Carcinoma of cervical stump	7	4	..
Recurrent carcinoma of vagina after hysterectomy	6	16	..
Epithelioma of vagina	10	17	2
Carcinoma of urethra	1	6	1
Carcinoma of bladder	2	4	..
	107	281	24

followed, so likewise we also note that postradial vesical irritability and rectal tenesmus and proctitis have largely been eliminated, as only a very few of this series have complained of these symptoms. The relief from hemorrhages and various discharges still stands in the same favorable ratio as set forth in our paper of last year. For full details bearing upon our methods of applying radium, we refer the reader to this same source. While, as we have constantly maintained, the treatment of cancer

TABLE II

SUMMARY OF LIVING CASES AFTER IRRADIATION

	Under 1 yr.	1 to 1½ yrs.	1½ to 2 yrs.	2 to 2½ yrs.	3 to 4 yrs.	4 to 5 yrs.	5 to 6 yrs.	6 to 7 yrs.	Not Traced	Total
Carcinoma of cervix	8	7	6	5	7	8	6	9	18	74
Carcinoma of fundus	5	5	2	4	1	3	0	1	3	24
Carcinoma of cervical stump	1	..	1	2	2	1	..	..	..	7
Chorio-epithelioma of vagina and cervix	..	..	..	1	..	1	..	2	..	4
Recurrent carcinoma of vagina after hysterectomy	2	..	..	..	1	1	1	1	..	6
Epithelioma of vagina	2	1	..	4	..	..	2	1	2	12
Carcinoma of urethra	..	..	..	..	..	..	..	1	1	2
Carcinoma of bladder	..	..	..	..	1	..	1	..	..	2

TABLE III

SUMMARY OF DEATHS AND DURATION OF LIFE AFTER IRRADIATION

	Under 1 yr.	1 to 1½ yrs.	1½ to 2 yrs.	2 to 2½ yrs.	2½ to 3 yrs.	3 to 4 yrs.	4 to 5 yrs.	5 to 6 yrs.	6 to 7 yrs.	Not Stated	Total
Carcinoma of cervix	118	35	19	15	9	7	3	1	1	9	217
Carcinoma of fundus	10	1	1	2	0	0	..	..	..	3	17
Carcinoma of cervical stump	1	2	..	..	..	..	..	1	..	..	4
Chorio-epithelioma	..	..	..	..	..	..	..	..	..	..	0
Recurrent carcinoma of vagina after hysterectomy	12	4	..	..	..	..	..	..	..	..	16
Epithelioma of vagina	9	5	1	1	1	..	..	..	..	..	17
Carcinoma of urethra	2	4	..	..	..	..	..	..	..	..	6
Carcinoma of bladder	2	2	..	..	..	..	..	..	..	..	4

Since the adoption of our improved method of application, we have anticipated that vesical and rectal fistulae as a result of irradiation would be of much less frequent occurrence, and we are happy to state that this forecast has been realized, for since August 1, 1920, this distressing sequel has occurred but once. We therefore, maintain more strongly than in our previous papers that irradiation, when properly applied, actually shields the cancer victim against this ugly accident. For the same reason that fistulae have not by irradiation falls far short of the ideals toward which the whole medical world so hopefully strives, nevertheless, it holds out the possibility of a cure for at least a few inoperable patients, and a vast alleviation of distressing symptoms and sequelae for those who must inevitably pass into the shades. Certainly, with such relief and actual cures, even though of a relatively small number, there can be no ground for the unfortunate expressions of pessimism which have been uttered by the occasional malcontent.

We submit our conclusions of last year, with slight modifications, as those to which we now adhere. However, this question in all its phases is still in flux, and we realize that our experience does not as yet justify us in making any fixed or unchangeable assertion, for we are but seekers for some better solution of this problem so destructive to the human race.

CONCLUSIONS

1. Radium in 100 mgm. amounts will yield most gratifying results if properly applied.

2. To pursue a set course without variation in the frequency of treatments, regardless of the progress of the healing, is hazardous.

3. To attain the best results, the first application should be done under nitrous oxid anesthesia, because a more careful examination may be made, and the radium can more advantageously be brought in contact with the malignant areas, either through radium tubes or by radium needles. Gauze packing instead of metal shields has proved of much greater value for protective purposes.

4. The process of cure passes through three stages: local destruction, connective tissue formation, and hyalinization.

5. A hysterectomy after successful irradiation of an otherwise inoperable case is hazardous and does not promote the best interests of the patient.

6. Results of irradiation in cancer of the cervix may remove this class of cases from the surgical field, although we have not yet completely yielded this point.

7. Cases of cancer of the fundus, unless too far advanced, or unless there is a critical surgical contraindication, should be submitted to hysterectomy, followed, from fourteen to twenty-one days later, by a light irradiation of the vaginal fornix.

8. Irradiation is dangerous immediately before or after an operation, or when employed in fresh operative fields.

9. Frequent repetitions of irradiation are probably unnecessary and possibly hazardous, as our observations point to the fact that the chief blow is struck at the first application. In no case that has required three successive treatments has there been a recovery.

10. The frequency of irradiation fistulae may be reduced to a minimum or almost completely avoided by the application of a well-placed vaginal pack, which pushes the healthy tissues away from the zone of intensive radiation.

STATISTICS AND TECHNIQUE IN THE TREATMENT OF FIBROMYOMA OF THE UTERUS BY RADIOTHERAPY*

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THE object of this study is to present an outline of the procedures employed in treating fibromyoma of the uterus and hemorrhage from other benign causes, to present a series of statistics giving the effects of the treatment on the symptoms and lesions, and more especially to study any late symptoms which might be ascribed to the methods used. There is much material available concerning the effect of radiotherapy on uterine hemorrhage and on the size of myoma, but not a great amount of accurate information concerning the artificial menopause and other late manifestations attributed to it.

The present information is derived from 250 cases, of which 203 were treated between June, 1914, and July 1, 1922. From the latter the statistical tables were compiled. The follow-up system at the Presbyterian Hospital requires that the operator examine his own cases in the follow-up clinic. Accordingly, about 80 per cent have been personally examined. One case has been completely lost. The remainder have given information through the social service or by correspondence.

Technique will be discussed from the broader standpoint. The application of radium or roentgen rays is simple compared with the problem of deciding on the proper treatment, preparing the patient for operation, and caring for her afterward. We have become convinced that in these benign conditions one individual or organization should care for the patient, and be prepared to carry out the proper treatment from start to finish, whether medical, operative or radiotherapeutic. Often the final decision must be left until the examination under anesthesia and diagnostic curettage. We have had two cases of dermoid cyst treated by roentgen rays for long periods, during which the error in diagnosis, possibly justifiable in the first instance, should have been corrected. One fibromyoma with associated adenocarcinoma was treated for two years without a diagnostic curettage. Operation in the first place would probably have cured it.

One phase of the preparation of the patient is not usually brought out, and that is the mental preparation for the menopause. This is emphasized because of the many misconceptions concerning the actual nature of this state and the more or less severe stress put on the patient by her sensations and her knowledge and by the love of the average individual for discussion of sexual matters.

The menopause has certain symptoms, and, in unfortunate individuals who have inherited a "neurotic constitution," others may follow. By recognition of the possibilities and proper handling of the patient, these can be avoided, for the most part.

The following is an outline of our procedure:

I. The most careful history and physical examination.

II. Preparation of the patient for all procedures (hysterectomy, radiotherapy).
   A. General: rest in bed, transfusion, salvarsan, etc.
   B. Psychotherapeutic: instruction of the patient in the nature of menstruation, the menopause, and the symptoms to be expected; outline of what she may expect in the way of predictions and observations from friends, lay and medical; instruction as to her reactions toward these.

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III. In the operating room, which is prepared for all procedures.
   A. Examination under anesthesia, including diagnostic curettage.
   B. Final diagnosis and decision:
      1. Some form of excision is performed if the patient is a good surgical risk; if she is under thirty-eight years of age; if the mass is over 15 cm. in diameter; if the diagnosis is obscure (especially if ovarian tumor is probable); if there is evidence of degeneration or inflammation in the growth; if there are submucous pedunculated myomata; if the pain or urinary symptoms are the important factors.
      2. Radium is used if the woman is over thirty-eight years of age and bleeding is the important symptom; in younger women with definite myoma where operation is contraindicated; and in young women without myoma suffering from uterine bleeding associated with tuberculosis or other serious disease, where subsequent pregnancy would not be advisable.
      3. Dilatation and curettage, followed, if necessary, by roentgen rays, are employed in young women where it is desired to cause a temporary menopause or merely lessening of the flow. Even moderate doses of radium in the uterus cause sclerotic changes which predispose to dystocia. Roentgen rays are therefore preferable.

Radium is given in doses of about 1,200 to 1,500 mgm. hrs. in women of forty years or more, with the uterus and ovaries in normal relationship. This is increased if the bleeding is thought to be due to ulceration, if the tumor is of such size as to increase the distance from radium to ovary (according to the law of inverse squares), and in young women where a permanent menopause is desired. The radium acts on the endometrium, the uterine muscles and the ovary. It is distributed, therefore, in small units so as to minimize as much as possible the slough in the endometrium. It is placed well in the fundus to avoid the cervix if possible. A chronic cervicitis started by radium and made persistent by a secondary infection may prove troublesome. The Dominici tubes are placed in rubber tubes 1 mm. thick.

Supplementary roentgen-ray treatment is given to a large tumor where it is believed that a permanent menopause will not result from the intrauterine application of the radium. It is used whenever there is a recurrence of bleeding after it has been once stopped, more especially if the recurrence seems to be persistent.

The effects of radium on the symptoms are indicated in Table I. The columns represent the different problems which present themselves: that of the adolescent or young woman, that of the woman in the active childbearing period, and that of the woman in whom the question of childbearing is negligible. The ages given represent the general averages. The important matter in making the decision as to a woman's sexual age is her general appearance and behavior. Some of mature years have all the youthful characteristics of women much younger, and desire children.

The last two columns represent cases where the lesion itself overshadows the question of age. The submucous pedunculated myoma is arbitrarily so named when the height of the protruding mass equals its diameter. This standard is made for practical purposes, because I believe that with so much protrusion, ulceration may exist, as in a definitely polypoid mass. From such an ulcer, bleeding will continue even after the onset of the menopause. Myomata are called large when they exceed 15 cm. in diameter.

The results of roentgen-ray and radium treatment are given together. The only difference noted is that the roentgen rays are slower, especially in fat patients, and that radium is less reliable in large tumors. One method has often been used supplementary to the other. With the intrauterine application there is the added element of aseptic surgery and usually anesthesia.

In women under twenty-five years of age, an attempt was made, in all but one case, simply to regulate menstruation. This was accomplished in all but one case, which has a permanent menopause (followed seven years). In the odd case a successful deliberate menopause was produced. It is interesting to note that one girl began to bleed after seven years of normal menstruation. This is now con-

TABLE I

Bleeding	Total Number of Cases	No Myoma Present			Myoma Definite			
		Under 25 Yr.	25–38 Yr.	38 Yr. and Over	25–38 Yr.	38 Yr. and Over	Sub-mucous, All Ages	Large, All Ages
Became normal	12	8	2	..	..	1	1	..
Became normal (excess recurred after 7 years)	1	1	..	..	..	..	..	..
Stopped immediately	70	..	5	23	2	28	5	7
Stopped after 1 month	41	..	4	18	..	15	1	3
Stopped after 2 months	26	1	0	8	1	10	..	6
Stopped after 2–6 months	20	..	3	5	1	5	..	6
Stopped after 6–12 months	1	..	..	..	..	..	..	1
Stopped and recurred later and Became normal	5	..	2	..	3	..	..	..
Stopped spontaneously	9	..	..	2	2	4	..	1
Stopped after radiotherapy	6	2	..	1	..	..	1	2
Failed to stop with first dosage and Stopped after radiotherapy repeated	2	..	2	..	..	..	..	..
Became normal after radiotherapy repeated	7	..	..	3	..	3	..	1
Satisfactory result from radiotherapy	200	12	18	60	9	66	8	27
Operation required for bleeding	3	..	..	..	..	..	..	..
Total number of cases	203	..	..	..	..	..	..	..

TABLE II

Other Symptoms	Total Number of Cases	No Myoma Present			Myoma Definite			
		Under 25 Yr.	25–38 Yr.	38 Yr. and Over	25–38 Yr.	38 Yr. and Over	Sub-mucous, All Ages	Large, All Ages
Dysmenorrhea:								
Relieved	13	1	3	3	2	2	..	2
Unrelieved	0	..	..	..	..	..	..	..
Total number of cases	13	1	3	3	2	2	0	2
Pain of other nature:								
Relieved	14	..	..	3	1	7	..	3
Unrelieved	23	1	1	5	..	11	..	5
Total number of cases	37	1	1	8	1	18	0	8
Urinary symptoms:								
Relieved	10	..	..	..	2	7	..	1
Unrelieved	10	1	..	2	..	6	1	..
Total number of cases	20	1	0	2	2	13	1	1

trolled by pituitary extract. In women over twenty-five years of age, the results have been fairly uniform. Three women were operated upon because of continued bleeding, due, we believe, to insufficient dosage. In two, the calculation was incorrect (400 and 500 mgm. hrs. respectively) and in the other a broken radium tube was used. One case of a large myoma with many submucous nodules

TABLE III

	Totals	No Myoma Present			Myoma Definite			
		Under 25 Yr.	25–38 Yr.	38 Yr. and Over	25–38 Yr.	38 Yr. and Over	Sub-mucous	Large
Immediate Symptoms and Conditions								
Death	1	0	0	0	0	0	0	1
Pain	4	1	0	2	0	0	0	1
Discharge	32	1	5	6	1	10	5	4
Local infection	3	0	0	0	0	2	0	1
Slough	2	0	0	2	0	0	0	0
Pathology overlooked	2	0	0	1	0	0	0	1
Remote Symptoms and Conditions								
No hot flushes	23	3	3	4	3	8	0	2
Hot flushes, mild	129	6	11	45	6	38	5	18
Hot flushes, severe	17	1	2	5	0	4	2	3
Total observed	169	10	16	54	9	50	7	23
Nervousness, unchanged	33	4	1	5	4	14	0	5
Nervousness, improved	60	4	11	18	2	14	0	11
Nervousness, slightly increased	48	1	2	25	3	10	2	5
Nervousness, greatly increased	5	1	1	0	0	2	0	1
Total observed	146	10	15	48	9	40	2	22
Age appearance, unchanged	55	5	..	..	..	34	3	13
Age appearance, younger	20	3	3	5	0	2	1	6
Age appearance, older	7	3	2	1	0	0	0	1
Total observed	82	11	5	6	0	36	4	20
Secondary sexual characteristics, changed	2	0	..	2	..	..	..	..
Secondary sexual characteristics, unchanged	102	6	13	35	19	7	4	18
Total observed	104	6	13	37	19	7	4	18
Libido, unchanged	36	3	5	9	3	10	2	4
Libido, increased	2	1	..	1	0	0	..	..
Libido, diminished	2	..	..	..	0	2	..	..
Total observed	40	4	5	10	3	12	2	4
Blood pressure, unchanged	82	5	12	23	2	24	4	12
Blood pressure, increased	16	..	0	6	0	8	1	1
Total observed	98	5	12	29	2	32	5	13
Subsequent pregnancy	2	1	0	0	1	0	0	0
Subsequent disaster, preventable by operation	1	0	..	1	0	0	0	0
Final result, satisfactory	161	7	13	55	6	52	7	21
Final result, qualified by errors of physician, etc.	11	3	2	3	1	..	..	2
Final result, unsatisfactory, because of radiotherapy	6	2	1	..	..	..	..	3

and pedunculated myomata needed operation in the first place, but had a severe anemia, continuing hemorrhage, and a septic thrombophlebitis. After the temperature had quieted down, she was given radium and then *x*-rays. The excessive hemorrhage stopped immediately, and all bleeding stopped at the end of a year. After her general condition had become normal she was operated upon because of continued pelvic pain and urinary distress.

A general summary of Table I shows that the bleeding either ceased or became normal in 40 per cent of the cases after one radium application of *x*-ray series, within a month after operation in 21 per cent, within two months in 13 per cent, and within six months (usually three) in 10 per cent. Fourteen and one-half per cent had recurrences and required supplementary treatment or stopped spontaneously, leaving about 1.5 per cent (three cases) of complete failure. Among the different types of cases the results were more or less the same, except that they were uniformly slow in tumors of large size.

Dysmenorrhea stopped in all cases, showing that the pain did actually depend on menstruation. On the other hand, pains in various parts of the body and unassociated with menstruation were not satisfactorily relieved, nor were urinary symptoms. Many of these had known causes, such as gall-stones, but they are included because they form part of the problem. The effect on the size of the mass varied greatly; so much so that a clean-cut table could not be made. In 105 cases in which the mass was large enough to measure, there was reduction in all but one. This woman had a moderate radium dose which made menstruation become normal. The mass had not reduced in size. The most rapid reduction was in a mass 20 cm. in diameter which could not be made out after six months. The slowest was in a mass 15 cm. in diameter which was reduced to 8 cm. at the end of three years and has remained so through four more years. It has seemed that when the effect of the radiotherapy in the ovary was slow and the artificial menopause late, there was a similar slow diminution of the mass. While radiotherapy will almost universally cause a reduction in the mass after a time, it is, at best, slow. I feel, therefore, that if size or other mechanical difficulties furnish indication for treatment, excision is the procedure of choice.

The immediate effect of the treatment on the individual has been slight in the majority of cases. With the roentgen ray there has usually been a little malaise; one patient had diarrhea. Most of them were nauseated; rarely one vomited. Following the intrauterine radium application the symptoms were the same, together with those which depend upon the surgical procedure. Death from pulmonary embolism occurred in one case. I believe this accident would not have occurred, had our present practice been followed; that of keeping in bed for a few days before operation, all cases with large tumors, or with any symptoms suggesting inflammation or degeneration. Postoperative pain has been severe in only one case. There was usually some discomfort immediately after operation, which we attribute more to the packing than to the radium. There was also a vague sense of heaviness, which often lasted for several days.

Discharge was important in 30 cases. It seemed to be of two kinds. One was a profuse watery flow, either intermittent or continuous, and was stopped by supplementary roentgen-ray treatment. This I believe to be a flow due to a perversion of the menstrual mechanism. The other discharge is mucopurulent, continuous for a long time, and is like that from any ulcerating surface. I believe this to be due to the superficial slough caused by the radium. In one patient there was a gross slough due, we think, to the combined effect of the radium and the disturbance of the circulation in the cervix caused by the removal of several pieces of tissue for examination to exclude carcinoma. In 3 cases there was a distinct infection. In one case the cause was faulty technique. In the others we think it was due to the opening up of an old infected cervix. There has been no sign of inflammation in the cases treated by *x*-ray. The inflammation is apparently due to the surgical

procedure, and not to the action of the rays on the latent foci.

More interesting than the immediate results after the radium are those which are expected and sometimes feared as sequelæ to the termination of menstruation. Certain symptoms seem constant, whether the cessation has occurred at the expected time or has been precipitated artificially. In addition, there is a long list of inconstant symptoms and conditions which occur coincident with or following the normal menopause, whether they are due to changes in the reproductive system, merely incident to the time of life, or what not.

Radium and *x*-rays produce in the ovaries and uterus changes which closely simulate those occurring in old age. There follows the same effect on menstruation. Here is presented, then, an opportunity to study experimentally the secondary effects of the menopause.

In preparing an outline, the literature was searched to find what the symptoms of the normal menopause were, and, if taken from the beginning, they were found to include everything from alopecia to zoster. With increase of medical knowledge this list has diminished greatly. The symptoms and conditions in the accompanying tables indicate those which are usually discussed today.

Hot flushes, whether felt as a distinct flush, a sweat, a rush of blood to the head, sudden tingling or numbness, seem to be of the same nature. This symptom is the one constant manifestation, and by it one can almost determine the presence or absence of the menopause. In analyzing the figures, one is struck by the fact that while nearly all have some degree of flush, there are only a few who are greatly disturbed by them. When they are present, they usually insure the permanency of the result. When they suddenly disappear, there is often a return of menstruation.

The study of blood-pressure has not been satisfactory. There has been such variability in the readings on the same individual within short periods that I feel that in ambulatory patients better standardization of the conditions under which the readings are made must be devised before the data will be accurate enough for serious study. In one woman the systolic pressure dropped from 190 mm. to 120 mm. in two hours.

Secondary sexual characteristics (changes in figure, contour of face, loss of attraction to the opposite sex, atrophy of the breasts and external genitalia) have not changed, with the exception of one woman whose breasts definitely shrank. In two others there was a constriction of the vaginal outlet, due, we believe, to the use of irritating antiseptics. As in the normal menopause, sexual desire has been affected almost not at all. The two with diminished and the two with increased desire are not explained. Several women took on weight. An equal number lost. The former gained, we believe, because of restored health; the latter lost because, although in fair health, they had been kept inactive by the continued loss of blood, while with the return of normal life they were able to get the proper exercise.

Ageing (loss of ambition, wrinkling of the skin, graying of the hair) is difficult to estimate. In the course of seven years one is likely to look older. On the other hand, many haggard women with restored health and gain in weight looked and behaved very much younger after the treatment. As far as can be judged, the cessation of menstruation has neither hastened nor retarded old age.

Nervous symptoms, mild or severe, are the symptoms most thought of and feared by the average woman who thinks at all about the menopause. In this series, the majority of the patients were either unaffected or more or less improved in their general reactions, emotional control and so-called nervousness. A goodly number were more irritable and became more nervous. The sensations of the former group may be explained by the fact that many of them were so depleted by the bleeding and worn out by the worry of its significance, fear of operation, etc., that the mental relief, after the cure was established, more than offset any natural irritability that would follow the cessation of menstruation. There are some, however, in whom this would not apply. It may be said, then, that a certain amount of

irritability will often, although not always, follow the cessation, and should be expected.

Severe nervous disorders of a degree to demand special attention have occurred in five of the series. One patient was the only unmarried daughter of a moderate-sized family, had always been pitied and protected by her brothers and sisters, had become hypochondriacal, and had developed a definite anxiety neurosis. She was antagonistic and distrustful, and had a minor hysterical attack during the first consultation. At the diagnostic curettage she awoke, screaming that she had been operated upon against her will. After *x*-ray therapy she developed hot flushes, began to brood over their significance and developed a psychosis of the melancholic type. She was kept in a sanitarium for about six months and has been at her previous normal level ever since (five years).

The second case was one of frank melancholia. The symptoms were overlooked in the diagnosis. She developed acute symptoms while in the hospital and was sent to an institution three weeks later. The case has little to do with the question of the menopause, but shows how, in outlining the treatment, one must be on the lookout for symptoms of nervous disease which may readily be overlooked when the anamnesis comes from the patient herself. Subsequent changes may be readily blamed on the operation.

The third and fourth cases were treated with full knowledge. Along with their bleeding, they presented well-marked psychic symptoms. At the suggestion of Dr. Samuel W. Lambert, one of them, suffering from a psychoneurosis of the paranoid type, was treated in the hope that the neurotic symptoms, present for twenty years, but exaggerated for one year, might be reduced to their previous state by the completion of the menopause changes. After the radium, there was considerable increase in the intensity of the symptoms for about six months. After that, they became much less severe, and now have only periodic mild recurrences (four years). The other was a case of dypsomania which had existed for years and was unaffected by the precipitation of the menopause. The fifth case is of a woman always of low mentality who developed an anxiety neurosis coincident with the cessation of menstruation. The previous nervous condition could be estimated with difficulty because of the poor responses to questions.

The causes of these various phenomena are of course involved in the causes of psychoneurosis in general. I can only give an outline of them as they appear from observation in the present series.

Causes of psychoneurosis of the artificial (radiotherapeutic) menopause:

I. Actual physiological changes due to loss of or alterations in secretions from the ovary or other organs concerned in menstruation.

II. Causes of psychoneurosis in general:
   - A. Heredity; previous nervous disorders.
   - B. Physiological and anatomical changes due to intoxications, syphilis, vascular changes, etc.
   - C. Bad mental environment:
     1. The development of bad mental habits in general.
     2. The development of bad mental habits concerning menstruation and the power of reproduction, and their importance to the individual; especially the consequences of their cessation.
        - a. Traditional confusion of the importance of menstruation to the species with its importance to the individual: the attitude of the community toward the woman as a breeder and little else, up to a few decades ago: the practice of "Suttee"

in India where the widow is burned on the funeral pile of her dead husband: the automatic divorce of the Chinese wife who fails to become pregnant within a year after her marriage. The traditional stigma resting on the childless married woman and the "old maid."

b. Fear of disease: those incident to age (cancer, insanity, cardio-renal disease) and those diseases in which amenorrhea is an early symptom (tuberculosis).

c. Fear of senility with loss of good looks, attractiveness to the opposite sex, libido, etc.

d. Fear of losing the feminine characteristics (broad coarse features, hair on the face, bass voice).

e. The vague tradition that the change of life involves the enduring of discomforts and dangers of a nature unknown or very vague to the woman.

3. The constant arousing of one or more of these thoughts by

a. Frequent hot flushes.

b. Actual slight increase in nervousness.

c. Bad advice from gossiping friends and relatives and careless physicians.

One of this group of patients consulted a prominent surgeon who told her to avoid radium by all means, because the last patient of his who had had radium was "crazy as a bedbug and hunting . . . (one of our esteemed members) with a hatchet."

In trying to prevent these nervous manifestations, we should avoid giving the treatment to one who is definitely psychoneurotic. We should further protect those receiving it by proper teaching of the truth about the menopause as we see it, and we should counteract the external influences which will, in the majority of cases, tend to arouse these anxieties.

Concerning the actual physiological effect of the radium on the ovary, and thereby on the individual, the tabulated evidence is only partly helpful. It may be safely argued that the action being most severe on the ripe follicles may spare enough to permit a supply of internal secretion sufficient to prevent the various changes which might be expected to occur after a total destruction. The process is in close imitation of nature, however, and the information therefore suggestive.

There have been two pregnancies, one normal and the other terminated after six months following a fall. There was a dead macerated fetus.

Of the various accidents and changes which might occur in a fibromyoma (toxemias, degenerations, inflammations, sloughing, etc.) none has occured. One patient died in another city, shortly after the treatment, with a diagnosis of carcinoma of the uterus. This was either a mistaken diagnosis, or else we overlooked the carcinoma at the curettage. There was no tumor, so that the only influence of this case on the future procedure will be to question the absoluteness of the information obtained by curettage and from the microscopic examination.

An attempt was made to form a general estimate of the desirability of the method, balancing the harm done with the benefits obtained as tabulated above in each case. Such a survey shows that the method was unqualifiedly successful in 91 per cent of the cases. In 3 per cent, more harm than good resulted from the treatment, and in 6 per cent, errors in judgment or technique qualified the result.

CONCLUSIONS

I. Radiotherapy of a myomatous or grossly normal uterus will
   a. Stop all bleeding not due to ulceration.
   b. Cause a myoma to shrink more or less rapidly.
   c. Stop dysmenorrhea.

II. Radiotherapy will give only partial results in the relief of
   a. Pain not associated with menstruation.
   b. Urinary distress.

III. As a result of the artificial menopause from radiotherapy
   a. Hot flushes are the rule.
   b. There is in some patients an increased nervous irritability.
      1. In the majority of patients nervousness is diminished probably because of the improvement in their general condition.
      2. Patients suffering from nervous disorders may be made worse.
   c. Changes in secondary sexual characteristics and in sexual appetite and satisfaction are negligible.
   d. Blood-pressure studies are unreliable. There seems to be an elevation in blood-pressure in 16 per cent of the cases treated.
   e. Normal pregnancy is possible after temporary menopause

DISCUSSION ON PAPERS OF DRS. STACY, SCHMITZ, FIELD, BURNAM, CORSCADEN AND CLARK*

DR. CASE. It seems to me quite futile to attempt to discuss these papers. I enjoyed hearing these reports from workers in the radium field. I wish to mention in regard to the benign conditions, that we appreciate very much the technique and combined treatment.

Our attention is more or less focused on malignant conditions, and it seems to me that one can in a few words summarize the lesson that comes to us from these papers. It is that, first of all, we need a careful examination. Following this, based upon our experience, we must have a plan. This plan must include the use of every known means to combat cancer, and we must work it in a grand effort to put the offensive over at the first assault. At no subsequent treatment do we have as good a chance of conquering the disease as we have at the first application. We must therefore plan to give a complete dose at the first seance. I do not mean by this, in the first twenty-four hours; but during the first series of treatment, which ought to be completed within the shortest reasonable time. It seems to us that the work of Clark, Burnam and others proves this. Then we must follow up the case in order to know what to do in the future.

As to radium or operation, it seems to me we have our answer. The tendency is toward more radiation and less operation; and if the cases are such as Dr. Clark and Dr. Burnam recite to us—Burnam had 15 cases of inoperable cancers alive after eight or nine years—how much better agents should we have than radiation in the operable cases? It seems to me, Burnam has taken the stand that we must support, that radiation is justifiable in all of these cases, and that for the present we must use a combination of radiation and operation in cases permitting.

I am glad to hear the discussion concerning pre- and postoperative radiation. My feeling is that pre-radiation is more valuable than post-radiation. I am in favor of the filtered needles in preference to the bare. The filtered have to be withdrawn, the bare do not, but I think the results are better with the filtered.

I have been rather impressed by a number of inoperable cases that have lived three, four or five years without anything being done. Is it possible to get some statistics for comparison?

I wish to express my appreciation and the appreciation of the whole society to these essayists for giving us such a splendid résumé of the entire subject.

DR. BOWING. It is encouraging to compare the new cases with the old cases in which we gave one treatment, and then another in two or three months, and so on. Eventually the entire vagina was cicatrized, with or without a

*Papers read at Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., May 22–23, 1922. Those of Drs. Stacy, Schmitz and Field appeared in October, that of Dr. Burnam in November, and those of Drs. Corscaden and Clark precede this discussion.

vesicovaginal or rectovaginal fistula. In the group that has been treated according to our present method, we have not encountered a single fistula that can be attributed to the treatment alone. I am sure that the ultimate results will be better. The medullary, proliferative type of cervical carcinoma responds more readily with a return to normal appearance of the structures previously involved. The infiltrating schirrous type is less favorably treated.

Since 1919 we have been using the knee-chest position with a Sims speculum and direct light, so that we can see just what we encounter. With a uterine sound one can palpate and measure the involvement. Then it is easy to fill the vaginal cavity with gauze. One does not have to traumatize to pack away the vaginal or rectal walls. The walls balloon out with the inrush of air. If there is a good perineal floor, the radium applicator will be retained in position. If not, we place adhesive strips over the perineum, which gives support to these structures. The cervical and uterine canal is divided for convenience into three parts: an anterior part includes the face of the cervix and one inch of the cervical canal, a middle part includes the second inch of the cervico-uterine canal, and a third part includes the lumen of the fundus.

In favorable cases for radium treatment, a 2,400 mgm. hours' dose is placed in each area and three vaginal treatments of 700 mgm. hours each, making a total of 9,300 mgm. hours. The broken dose method is used with an interval of forty-eight hours between treatments. The Universal silver tube applicator containing 50 mgm. radium sulphate is used. No added filtration, except 1 mm. brass, is used in the vaginal applicator. Very little trauma, if any, occurs in inserting the applicator into the canal. It is essential to treat the deeper portions of the tumor area.

I have discontinued using lead in the vagina because I think it is detrimental on account of its secondary rays. In cases in which it has not been used, there is less vaginal irritation. When the radium applicator is placed in deep cavities, we use a copper wire, which not only offers a way of putting it in and holding it, but facilitates and insures removal. Radium causes a characteristic reaction in the tissues exposed, similar to nature's own method of combating the disease.

I am confident that our present methods will give more lasting results, and that a combination of irradiation and surgery is best in well-selected cases.

Dr. Boggs. We are often led to believe that because gynecologists use radium alone, it is not necessary to use *x*-rays from the outside. As Dr. Burnam said, we would like to have some cases treated with *x*-rays alone from the outside and note the effect. We know we get a decided effect on the lymphatic glands. I agree that it is not necessary to treat the local growth with *x*-rays, but the great majority of cases have no glandular metastasis; and in many of those cases that we are treating, we are getting no effect on the metastatic glands because there are none present; however, we know that some primary cases have metastatic glands at operation. In those cases that are treated with radium alone, we will not have the same result as when we use *x*-ray upon the outside.

Dr. Stacy. A review of all cases of carcinoma of the cervix treated at the clinic has recently been made. This series includes all methods of treatment employed; such as the use of the simple cautery, the Percy cautery, the Percy cautery followed immediately by hysterectomy, the cases treated with radium only, and with radium and surgery. The results have not been very encouraging. This review brings out the importance of making an early diagnosis and instituting early treatment, as the duration of the disease and the age of the patient influence the ultimate results more than the method of treatment employed in the individual case.

Now we are trying out a series of 100 cases of early carcinoma of the cervix, using the full dosage of radium, and following this in two or three weeks' time by hysterectomy.

Dr. Clark. Great care should be taken to avoid losing a radium needle in the cervix or adnexa, for, unless soon found and removed, the result will be serious. Such an accident did occur in my hospital, but happily, the needle was quickly found and removed. On this occasion, twelve 10-mgm. needles had been threaded on heavy braided silk and inserted into a neoplasm of the cervix and vagina. All except one were removed without trouble. With this one, however, the thread must have been cut or damaged by the special forceps with which the needle had been inserted, as it broke, and all idea of the position of the needle was lost. In this emergency it occurred to me that an ordinary sewing needle might be threaded and inserted as near as possible where the radium needle was thought to be, and stereoscopic radiographs made. This was done, and the position of the lost needle found to be about one-half an inch from that of the sewing needle. A small incision was made, and the needle readily withdrawn, within twenty minutes of the discovery of its loss.

Dr. Schmitz (closing discussion). I wish to say that the vulnerability of cancer of the

cervix is very low. In other words, the majority of patients that come to us come when there is invasion of the contiguous tissues and of the lymph-nodes. It is necessary to find a means of attacking this, and I believe that lies in the combination of *x*-ray and radium. We are just now doing a series of cases with *x*-ray alone, and if we can reach fifty cases, I will report the results.

So far as the results of radium and operation are concerned, I feel that the more I see of either method, the more I am inclined to give all the credit to radium and *x*-ray, and not to results of operation. In our cases in which we have followed the operation with radium, we have had disastrous results, and since we have learned to leave them alone, they have done well.

It also seems to me that in carcinoma of the uterus, the action of the radium is not spent on the ovary at all, but on the endometrium. The ovaries are at some distance from the canal, and the intensity of the radium is so small with the milligram hours used, that they are not disturbed, and that explains why these patients will often begin to menstruate again, having a perfectly normal menstruation. We do not attempt to radiate the whole uterine cavity for the reason that we wish to avoid cicatrizing the internal os. We have seen several cases where this has resulted in stenosis, and, in a few cases, in atresia.

Dr. Burnam (closing discussion). I am much interested in the comments and discussion. What I meant by radiation and its effects on squamous cell carcinoma of the cervix was that in order to evaluate this method, it should be used in some cases alone. That is the only way to determine its value. If, as is contended by the Erlangen School, the method is very effectual, there will be nothing lost by radiating and watching for a few weeks. If the method is a failure, we can then have recourse to local radiation or to operation, or to both.

I was interested in the dosage which Dr. Stacy reports in her cases. We use 1,500 mc. hours as an average dose, and we have had a great many patients who began menstruating after a period of a year to several years, some as late as four years.

Dr. Field's case interested me very much because I had sent to me a patient whose brother-in-law had amputated the cervix, which, on microscopical examination, proved to be the seat of a squamous-cell carcinoma. When I saw her, there was a well-healed scar, and no sign of cancer. I gave 3 gm. hours of radiation over the vaginal vault and opening to the uterus. This patient went for some months without menstruating and then became pregnant. The question of what to do became a pressing one, and I advised that she go to a good obstetrical hospital and be prepared to have a Caesarean section done at full time. That was not done. She was delivered of a normal child, but on the third day following delivery, for reasons which I have not yet learned, she died of hemorrhage.

Dr. Corscaden (closing discussion). The question of the mode of action of radium has interested me greatly. I do not believe that a permanent cessation of bleeding will occur unless there is a permanent menopause, brought about through the destruction of the Graafian follicles. We have four specimens to study, two from hysterectomy because of failure to cure, and two uterine removed because the microscopic findings suggested adenocarcinoma. In one specimen, there was, three weeks after the application of radium, only the most superficial action on the endometrium. The ten-day specimen shows an eschar 2½ cm. long by 1 cm. wide. Beneath the mucous membrane were spots of tiny extravasations of blood for a depth of 1 cm. In all specimens, there was marked thickening of the lining of the vessels and considerable thrombosis. The two specimens of ovary showed definite, distinct changes, in that the action on the endometrium is limited to the narrow zone about the radium; so that with normal endometrium present, menstruation may occur, unless the ovarian element is removed.

ESTIMATION OF CARDIAC VOLUME BY ROENTGENOLOGY *

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DR. Stewart has kindly invited me to present at this meeting a paper on the estimation of the size of the heart by roentgenology. I regret that I cannot attend the meeting to present it personally and take part in the discussion.

Estimation of the size of the heart is only one of the ways in which roentgenology helps in the diagnosis and treatment of cardiac conditions. Note that I add "and treatment" here. Roentgenology offers real aid in study of the action of drugs, rest and exercise on the heart. Fully to treat of the subject of this paper would require an extended review of the whole field of cardiac roentgenology, of the anatomy, the physiology, and the pathology of the heart and of the treatment of heart disease. This, of course, is out of place here. I shall confine myself as strictly as possible to a discussion of cardiac volume from the standpoint of roentgenology.

The first question to be considered is that of the value of a knowledge of cardiac volume in the diagnosis and treatment of heart disease. Is there value in a more exact method of estimating heart size than that offered by the usual method of percussion? This question should be answered before taking up that as to whether or not roentgenology offers this more exact method. That there is value in an estimation of the size of the heart is shown by the persistence and general use of cardiac percussion. If there is use in estimating the size of the heart, it seems clear that the more accurate the estimate, the better it should be. The value of the estimation of the size of the heart lies in the fact that the normal heart is closely adjusted in size to the size of the body. Probably no other organ in the body has so uniform a task to perform as the heart, or is so uniformly fitted to this task. In my paper in the *American Journal of Anatomy* for 1918 I have given a summary of the literature relating to the relation of the weight of the heart to weight, stature and age. All investigators of this subject have shown that there is a close correlation between heart weight and body weight, due probably to the need of a given mass of heart muscle to pump the blood to a given mass of tissue. The value given to heart weight in relation to body weight by different investigators varies somewhat because of different methods used. At death, the body is apt to be emaciated, especially during childhood. If heart weight is compared to cadaver weight the heart weight averages relatively high. If it is compared to estimated normal body weight it averages relatively low. The mean between the two probably approximates the normal relations. From the data referred to above I concluded that the weight of the heart throughout life approximates $\frac{1}{200}$ of the body weight (.55 per cent in males, .53 per cent in females). In estimating the ratio of heart weight to body weight at birth, the weight of the fetal membranes should be included with the body weight. In addition to the slightly smaller average relative weight of the female heart there are individual variations in heart weight within normal limits. Just how wide these limits are, obviously cannot be determined from cadavers. Observations on related animals such as apes might be of help here, but dogs are of comparatively little value, because, undoubtedly, variation in relative weight of dogs' hearts is vastly greater than normal variation in weight of human hearts.

The volume of the heart relative to heart weight depends partly upon the specific gravity of the tissues composing the heart, partly upon the fluids within the chambers of the heart and in the intrinsic vessels of the heart. The volume of the heart in diastole is therefore greater than the volume of the heart in systole. The specific gravity of the human heart is about 1.050. The volume of the heart tissue

* Read by title at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.

in cubic centimeters is thus about 5 per cent less than the weight in grams. In experiments on dogs, I found that in diastole the heart wall constitutes about 60 per cent of the total volume of the heart, the heart content 40 per cent. In the human heart in diastole, the heart wall appears to constitute about 50 per cent, the heart content about 50 per cent of the total volume, The methods used in making these estimates are given in the paper referred to above.

The normal heart is prepared to meet not only the usual demands of daily life, but also the exceptional demands of unusual exertion. After birth the left wall of the heart becomes much thicker than the right because of the greater force needed for the general than for the pulmonary circulation. As the child grows in size, the heart grows likewise to meet the needs of the body. In those called upon to do a large amount of muscular work, the heart probably normally enlarges slightly to accommodate itself to the special demands put upon it. Growth of the kind mentioned is called physiological hypertrophy.

In contrast to alterations in the size of the heart due to physiological hypertrophy, there are those due to a failure of the heart to meet in a normal manner the demands put upon it. On the one hand, we have acute dilation, in which the heart becomes over-distended in diastole, and loses the power to contract normally in systole. On the other hand, when the heart is subject to a constant load beyond the normal capacity of the heart muscle, as in case of valvular disease, or too frequently repeated great strains, as in case of athletes or mountaineers, the quantity of heart muscle may increase in amount, but with a loss of quality. This is called pathological hypertrophy. The borderline between physiological and pathological hypertrophy is not a definite one, but apparently most pathologists are inclined to consider that hypertrophy sufficient in amount to make the heart noticeably larger in size than normal is likely to be pathological. In the study of cardiac dilatation and of cardiac hypertrophy it is obvious that the more accurate the method of determining heart volume, the more valuable it should be. It is clear also that very accurate methods are needed if a study of heart volume is to include the study of volume in systole as well as in diastole and an estimate of cardiac output.

Does roentgenology furnish such a method? Smith and Bloedorn (*U. S. Nav. M. Bull.*, Feb., 1922) in a teleroentgenographic study of the hearts of naval cadets, came to the conclusion that the individual variability in size of normal hearts is so great that "any conclusion as to the relative size of a heart based on comparative dimensions, ratios, or relations to body landmarks is fallacious and should be applied clinically with great reserve," and state that they are "tempted to take sides with Lewis in his belief that the position of the apex beat indicates as well as any means at our command the relative size of the heart." They believe that the variation in size of normal hearts so far overlaps the variation in size of pathologically enlarged hearts that there is no great clinical value in an accurate determination of the size of the heart. That roentgenology offers the most accurate methods which we have of determining the size of the heart in the living, they do not dispute.

These authors are quite correct in concluding that the normal range of variation in size of the heart overlaps the field of variation in size due to pathological conditions. Hearts may be dilated or hypertrophied, and still be smaller in proportion to the size of the body than are some normal hearts. Relatively small hearts may be insufficient in size to meet the demands of the body, or they may be composed of exceptionally efficient musculature. Hypertrophy of the left ventricle is most likely to be diagnosed early by the roentgenologist by observation in the fluoroscope of a prominent apex; heart muscle weakness by the resemblance of the heart shape in diastole to that of a sack partly filled with fluid or by the bulging of the sides of the silhouette area in diastole during expiration as compared with that during inspiration; right ventricular dilatation or hypertrophy by the systolic contraction of the lower right border of the heart shadow; auricular distention by the bulging of the auricular regions of the silhouette contour. Zehbe's

recent contributions along these lines are of great value.* On the other hand, an accurate method of determining heart size is clearly necessary in studying the return of a dilated heart to normal size, or in studying whether a large heart is increasing in size under given conditions, and similar phenomena. At the University of Wisconsin we have found it of great value in following the hearts of athletes. As a rule, in a healthy athlete, the heart does not enlarge during the training season. On the contrary, it becomes more effective in systole. For effective work in study of cardiac conditions, repeated observations over an extended period are necessary. Accurate study of heart size is of importance here.

Admitting that accuracy in the estimations of heart size is of value in clinical medicine, and that roentgenology furnishes us with the best available means for this purpose, the next subject is that of the methods to be used in applying these means. While for various purposes in the study of the heart the fluoroscope and orthodiascope are invaluable, for the study of heart size the teleroentgenogram offers advantages which appear to make it the method of choice.

The distance from anticathode to plate commonly taken for this purpose, two meters, appears in general to be the most practical. Even at this distance, there is sufficient dispersion of the rays to make it necessary to allow for enlargement of heart silhouette over cardiac outline. At less distance a corresponding increase in allowance must be made. While less allowance need be made if a greater distance is chosen, the gain thus made does not compensate for the increased technical difficulties.

The position of the body is of importance. The chest wall must face the plate in order to reduce error from ray dispersion. The prone position presents technical difficulties in obtaining tubal distance, is somewhat uncomfortable for the patient, and tends, except in case of thin people, to press the abdominal viscera upward and thus obscure the diaphragmatic portion of the heart. The standing position is difficult to adjust and have maintained with uniformity. The sitting position with the patient leaning forward against an inclined plate-holder is superior to either the standing or the prone position, and should be used whenever conditions permit. Standards of heart size should be based upon this position, and when it is necessary to take pictures in other positions, due allowance should be made for variation in silhouette area. It is important that the plate-holder should be inclined, and not vertical. The slant of the plate-holder should be such that when the tube is at the top of the tube-stand and the anticathode is two meters from the plate, the central rays will be perpendicular to the surface of the plate-holder. The patient should sit well back on an adjustable stool. The chest wall should be against the plate-holder and the abdominal wall should be somewhat stretched by the backward tilt of the pelvis. The hands should rest on the top of the plate-holder. In this way, the heart is brought as closely as possible to the plate by force of gravity as well as by position, the pressure of the abdominal viscera on the diaphragm is relieved and the diaphragmatic portion of the heart is made more clear. The breath should be held at the end of a moderate inspiration while the picture is being taken. This insures greater distinction of outline and greater uniformity than to take the pictures by chance during quiet respiration. In general, deep inspiration at the time of taking the picture is not advisable, but for fat individuals it is the position of choice. Swallowing water so that air is introduced into the stomach, or the use of a small amount of Seidlitz powder frequently aids in making clear the apex of the heart. Otherwise, the less there is in the alimentary canal at the time of taking the picture, the better the picture is likely to be. The tube should be centered as nearly as possible over the center of the heart.

For routine work the diastolic silhouette of the heart is taken. For this purpose an exposure of a second is preferable to a shorter exposure. For special purposes, where it is desired to take one or more

* *Deutsche Med. Wchnschr.*, 1916. *Fortsch .*, 1918, p. 424. French roentgenologists have likewise added greatly to this field of work. See Martinez, Am. J. Roentgenol., 1921, viii, 491, and Vaquez et Bordet, de Coeur et l Aorte, Paris, 1918. Karshner and Kennicott have recently contributed an important paper. Am. J. Roentgenol., 1922, ix, 305.

pictures at definite intervals during a single beat, the exposure is reduced to a minimum and the period of the exposures is recorded on simultaneous electrocardiograms. Into the details of the technique of the methods for doing this I cannot here enter. Dr. Eyster and Dr. Meek are actively at work in this field.

Having taken the heart silhouette, the next step is to determine from it as accurately as possible the size of the heart. First, one should decide on the formula to be used in making reduction for the magnification of the silhouette due to ray dispersion. The most accurate simple method for doing this, when the two-meter distance has been used, is to measure in centimeters the anteroposterior diameter of the chest wall in expiration at the level of the sixth thoracic vertebra, divide this distance by three, and utilize the quotient to designate the percentage of area reduction; half this the percentage of linear reduction. Thus if the chest wall is 21 cm. thick, the silhouette area should be reduced 7 per cent, and the transverse diameter 3½ per cent to get the value of a sunlight silhouette. In my paper referred to above I have gone more into detail concerning this method. Unless the silhouette area is reduced for each individual to the sunlight area, variability of heart size will appear to be much greater than it is in reality.

Having now the silhouette and the formula for makng proper reductions in its measurements, the next thing is to make such measurements as will give the most accurate practical estimate of cardiac volume. Of the various methods of measuring the heart silhouette, the most widely used is the linear measurement of transverse width of the heart. This is popular because it appears to be objective. It does not, however, represent a definite diameter of the heart, but a measurement which varies with the shape and position of the heart. It is correlated with the transverse diameter of the thorax, the width of the heart being about one-half of that of the thorax. Different investigators, however, have come to different conclusions as to the exact ratio. For those who prefer a rough and ready estimate of relative heart size the cardio-thoracic ratio probably offers the best method but it gives no help in determining heart volume.* The transverse width of the heart, since it represents a variable measurement, not a definite diameter, cannot be used for this purpose. Efforts have been made to outline definite diameters, especially the long diameter of the heart. All these have suffered, however, from the difficulty of measuring these diameters between corresponding points of the heart in different hearts. By completing the outline of the heart and measuring the area we include all possible diameters within the field of the silhouette, and thus reduce to a minimum the error of comparative diameters. It is naturally more difficult to complete the margins of the heart silhouette than it would be to complete the margins of the shadow of an egg looked at through a slit, but by continuing the curves of each lateral margin into one another across the base of the heart and by connecting the lower ends of the lateral margins by a slightly curved line, the silhouette area can be completed with a fair degree of exactness. The same observer should be able to come within 2 per cent in estimating area at different times from the same photograph, and observers used to one another's methods should come well within 5 per cent. A variation of 5 per cent in area is approximately equivalent to an error of 7½ per cent in volume and to one of 2½ per cent in any given diameter. The area is measured readily by means of a planimeter. I give here four figures to illustrate the outline of the heart as seen from in front. Figure 1 illustrates a cadaver heart. Note that the transverse diameter of the heart is broad and the the great vessels at the base are short. The positions of the semilunar valves are marked by three short curved dotted lines meeting at a point. The position of the proximal origins of the mitral and tricuspid valves are roughly indicated by oblique curved lines. Figure 2 is from the silhouette area of the heart of a stocky individual. The outlines of the silhouette are drawn in heavy lines. The chambers of the heart and the great vessels are drawn in light lines as imagined seen from the front. The valves are indicated

*Hammer, G. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1918, xxv, 510. A good account of the relations of the transverse width of the heart to body weight, stature, chest-girth and age.

as in Figure 1. The base of the cardiac silhouette is shown by a curved dotted line. Figure 3 gives a similar representation of the heart of an individual of average build; Figure 4, that of the heart of an individual of relatively slender build. In the latter case the silhouette is taken at the end of deep inspiration to illustrate marked lengthening of the heart. The diaphragm is high on the left side because of a large gas bubble in the stomach. It is to be noted that the great vessels are much more elongated in the living than in the cadaver.

FIG. 1. Cadaver heart. The curved line in dashes at the base indicates the region through which passes the line used to demarcate the upper limit of the cardiac silhouette. The positions of the pulmonary and aortic valves are each marked by three short curved lines in dashes. Two longer curved lines in dashes indicate approximately the proximal origins of the mitral and tricuspid valves.

From the silhouette area, heart volume may be calculated with a fair degree of accuracy. In order to get a formula for doing this, I studied sunlight silhouettes of numerous anatomical specimens and models of the heart in various positions, and correlated these with the actual volumes of those specimens. I have described the method at length in the paper referred to above. That the calculated volume approximates the real volume I think is shown by the fact that cardiac output estimated from difference in silhouette area in systole and diastole corresponds closely with output estimated by other methods. This is true both in man and in dogs, as shown by the work of Eyster and Meek, as yet in part unpublished.

Having estimated the volume of the heart in a given individual, one naturally desires to compare this measurement with a standard of some kind. Such a standard may be the average of similar measurements made on individuals of similar sex, age, height or weight, or it may be based on a more generalized set of data. The standards which I proposed in the paper referred to

FIG. 2. Silhouette area of the heart and great vessels of a stocky man. Inside the silhouette area the ventral surface of the heart and the position of the valves have been schematically represented so as to correspond with the similar structures shown in Figure 1. The individual from whose roentgenogram the outline of this heart was traced was 27 years old; height 68 in.; weight 171.5 lbs.; chest girth inspiration, 41.2 in.; expiration 37 in.; thickness of chest, inspiration 9.1 in.; expiration 7.9 in.; pulse rate 82; systolic blood pressure 122; diastolic pressure 84; silhouette area 127.8 cm.; trans. width 13.8 cm.; cardiac volume 766 c.c. The individual was estimated to be 17.4 per cent above the average weight for stature. The volume of the heart was 9.5 per cent above the norm for stature, 7.1 per cent below the norm for weight. Individual taken seated. Moderate inspiration.

above and which were also published in the AMERICAN JOURNAL OF ROENTGENOLOGY for December, 1917, are of the latter type. They are based upon the following generalizations:

1. There is typically an approximately constant relation between size of heart and size of body. This may be expressed in terms of heart weight relative to body weight, of heart volume relative to body weight, heart volume relative to silhouette area, and of silhouette area relative to body weight. The following formulae are those which I have adopted to express these relations:

(1) $H = 5.5W$, (2) $V = \frac{5.5W}{.5187}$, (3) $V = 0.53A^{3/2}$, (4) $W = \frac{1}{20}A^{3/2}$. In these formulas H equals weight of heart in grams, W, weight of body in kilograms, V, volume of heart in cubic centimeters, A, area of silhouette in square centimeters. The above formulae express heart size in males. The female heart is about 5 per cent less in size for a given body weight.

FIG. 3. Silhouette area of the heart of a man of average proportions. Surface configuration and valves schematically represented as outlined above. The age was 22 years; stature 69.75 in.; weight 152 lbs.; inspiration 36.5 in.; expiration 32.9 in.; thickness of chest, inspiration 8.1 in.; expiration 7.5 in.; pulse rate 80; systolic blood pressure 108, diastolic 85; silhouette area 126 sq. cm.; trans. width 12.8 cm.; cardiac volume 750 cu. cm. The individual was estimated to be 1.5 per cent above average weight for stature. The volume of the heart was 3.7 per cent above norm for stature, 2.5 per cent above norm for weight. Individual seated. Moderate inspiration.

2. For a given height and age there is an average or typical body weight. The typical heart size is correlated with this typical body weight and hence may be correlated with the stature corresponding with this weight at a given age. Typical statures for a given body weight at a given age are given in the tables referred to above. These typical heights are based on the height weight statistics available at the time the table was prepared. More recent data suggest inconsequential changes in these estimates. Individuals tall for weight and age may be expected to have somewhat larger hearts than those of average build. Those short for weight and age may be expected to have somewhat smaller hearts than those of average build. By taking the mean between the silhouette area given in

FIG. 4. Silhouette area of the heart of a relatively slender man. Surface configuration and valves schematically represented as outlined above. The age was 45 years; stature 71.5 in.; weight 146.3 lbs.; chest girth inspration 38 in.; expiration 34.4 in.; chest thickness inspiration 9.1 in.; expiration 7.6 in.; pulse rate 88; systolic pressure 112, diastolic, 75; silhouette area 118.4 sq. cm.; trans. width 12.2 cm.; cardiac volume 676 c.c. The individual was estimated to be 16.4 per cent below average weight for stature and age, the volume of the heart was 19.5 per cent below the norm for stature, 3.5 per cent below the norm for weight. Individual seated. Deep inspiration.

the table as typical for the weight of a given individual and that given as typical for his stature and age, we obtain the best standard with which to compare the silhouette area of that individual.

There are no obvious advantages in comparing silhouette area with cutaneous surface area estimated from height and weight. I believe that this merely introduces additional sources of possible error. Smith and Bloedorn, who introduced this method, found it but slightly superior to the method of comparing silhouette area with body weight. They do not compare it with my method of taking height at a given age and weight separately into consideration. Their data are not expressed in such a way as to make possible a comparison of the silhouette areas which they found with those called for in my table. Comparison can be made between the average silhouette area for a given weight and the silhouette area given in my table for that weight. Such a comparison shows silhouette areas smaller for a given weight than those called for in my table. In part, this difference may be due to a difference in completing the cardiac outline. In the example of completed outline which they give, the base of the heart is cut off more abruptly than I would cut it off. The difference in method would not probably, however, make a difference of more than 4 per cent in estimating area. To some extent the relatively small average silhouette areas which they found may be due to build. In this case the average build of the cadets would be a stocky build, relatively high weight for stature. It seems probable, however, that the average silhouette areas in the individuals studied by Smith and Bloedorn, if stature and age as well as weight were taken into consideration, would be at least 5 per cent and possibly 10 per cent smaller than those given as norms in my table. This may be ascribed in part to discarding those with large hearts at the physical examinations preceding entrance into service, in part to sitting upright instead of leaning forward when the radiographs were taken. There is also the possibility that the norms which I give are slightly large. This has not, however, appeared to be the case at the Wisconsin Clinic. LeWald and Turrell's data (*Am. J. Roentgenol.*, February, 1920, p. 67) show that in the aviators which they studied the silhouette areas average for a given weight and height about 4 per cent less than the norms given in my table. This may be due partly to selection at the time of the physical examination for extrance into service.

In Table I is shown the frequency of deviation from the norms given in my tables, in three series of individuals Series 1 comprises 200 clinically normal males of various ages studied at the Wisconsin Clinic, Series 2, a similar group of 50 females, and Series 3, 70 of the individuals studied by LeWald and Turrell, the data for whom were applicable to this study. The data given in this table show that the average deviation in volume from the median in the 200 males was 9.2 per cent. This is equivalent to a deviation of about 6.1 per cent in silhouette area. The median group shows a deviation of 2 per cent in volume above the norms in my table. Half the cases lie between 10 per cent above and 6 per cent below the norms. Three-quarters of the cases lie between 15 per cent above and 11 per cent below the norms. This is equivalent to 10 per cent above and 8 per cent below the norms for silhouette area. In Series 2 the norms are taken at 5 per cent below those given in the table. This correction is made on the assumption that for a given weight the female heart averages 5 per cent below the male heart in volume. The median is about one per cent below the corrected norms. For this series, therefore, the correction should have been 6 per cent instead of 5 per cent. Fifty-eight per cent of the cases came between 9 per cent above and 9 per cent below the norms for volume. The average deviation in volume from the median group is 6.32 per cent, which is equivalent to about 4.2 per cent in area. Seventy-six per cent of the cases lie between 11 per cent above and 11 per cent below the norms. In Series 3 the comparison is with norms for area. The median is 4 per cent below the norms. Fifty per cent of the cases lie between 2 per cent above and 10 per cent below the norms. Seventy per cent of the cases lie between 3 per cent above and 13 per cent below the norms. The average deviation

from the median is 7.46 per cent. This is equivalent to a volume deviation of 11.19 per cent. In the three series the average deviation from the median is least in Series 2 (50 females), greatest in Series 3 (70 males studied by LeWald). In none of the series is the average deviation sufficiently large to throw doubt on the value of the method of using silhouette area in the estimation of heart volume. With increasing data, it will become possible to modify the norms in the direction in which these data point. From the data thus far at hand, I see no reason for altering those proposed. Furthermore, it does not seem to me, after making numerous attempts along similar lines, that the method proposed by Rohrer (*Fortschr.*, 1916, xxiv) of estimating heart volume from frontal and saggital views, or that of Köhler and Wechebach (referred to by Hammer, op. cit.) of estimating volume from stereoscopic pictures are either of them as likely to give approximately accurate results as that of estimating from the silhouette area of the frontal view.

TABLE I

Three series showing the number of cases with a given percentage of deviation from the norms in the Bardeen table. In each case the individual measurement is compared with the average of the norm for weight and that for stature and age. Series 1, 200 clinically normal males of various ages radiographed at the University of Wisconsin Clinic. Volume calculated from silhouette area compared with the norms. Series 2, similar series of 50 females, compared with the norms in the table reduced 5 per cent. Series 3, 70 of the aviators studied by LeWald and Turrell. Silhouette area compared with the norms. Median groups are underscored.

Per Cent of Deviation, Plus Dev.	Number of Individuals		
	Series 1	Series 2	Series 3
27.1–29	3		
25.1–27	1		
23.1–25	4		
21.1–23	5	1	
19.1–21	6		
17.1–19	2	1	
15.1–17	7		
13.1–15	11		2
11.1–13	4	4	1
9.1–11	10	5	5
7.1–9	14	3	1
5.1–7	16		2
3.1–5	9	3	3
1.1–3	13		6
0.0 1	5	4	2
Minus Dev. 0.0–1	8	4	3
1.1–3	13	6	7
3.1–5	12	4	6
5.1–7	11	2	8
7.1–9	12	3	5
9.1–11	9	4	4
11.1–13	9	1	3
13.1–15	5	3	1
15.1–17	2	1	3
17.1–19	3	1	3
19.1–21	1		0
21.1–23	3		2
23.1–25	1		1
25.1–27	1		
33.1–39			2

DISCUSSION

DR. MARTIN. I want to devote my time to a discussion of Dr. Bardeen's paper. He has, in the past, furnished us with much of value relative to roentgen-ray cardiac examination. One of his articles, published a short time ago in the *Journal of Anatomy*, represents an exhaustive study of this subject. However, I do not feel that his method of determining cardiac volume will prove to be of great value in studying the pathological heart. It is certainly true that any method which would give us an accurate estimation of the volume of the heart would be of great value clinically. But can we assume that a fixed formula will always give us such a value? You are all aware of the fact that the formula for the volume of a sphere is quite different from the formula for the volume of a cube. Therefore, I would hesitate to use the same formula in estimating the volume of the small spherical heart of early mitral stenosis and the long "beef tongue" shaped heart of senile myocarditis.

Dr. Bardeen's formula contains only one variable quantity; the silhouette area. He

states that an error of 5 per cent in this area will become an error of 7½ per cent in the calculated volume. In a word, the volume is not as accurate a figure as the area. Since the area is the only variable quantity, his formula can give us no information that the area does not give. It would seem wiser, therefore, to use the area as an index of cardiac size rather than the calculated volume.

The shape of the heart is usually changed when it becomes diseased. This change involves the anterior posterior diameter as well as the transverse diameters, and it seems to me that any formula designed to represent the volume should contain one variable symbol representing the anterior posterior diameter. This point can be easily illustrated in early mitral stenosis. The area of the heart silhouette may be increased very little, or not at all, but a fluoroscopic examination in the oblique position may show the dilated auricles extending well back into the posterior mediastinal space.

Dr. Bardeen is an advocate of the cardiac area as a measure of cardiac size. He states that the transverse diameters which many of us use are inaccurate because they change with the shape and position of the heart. It is just such changes that we wish to record in the pathological heart. The transverse diameters are drawn from the only well-defined borders of the cardiac area. The errors made in outlining the cardiac area will not be made along the right or left borders, but along the indefinite upper and lower borders. I cannot feel, therefore, that the area offers any great advantage, so far as accuracy goes. I am inclined to believe that were a half-dozen of the men in this audience to outline the same heart on a teleroentgenogram and measure the area with a planimeter, we would find considerable variation in the results.

Personally, I have been inclined to accept the cardiothoracic ratio as a fairly reliable estimate of cardiac size. Dr. Bardeen feels that this ratio is only a rough estimate, and he may be right. However, it seems to me that his method of estimating enlargement on the basis of average normals is also a rough estimate, and the difficulty lies in determining which is the rougher. After determining the cardiac area he looks up the average area for the patient's weight and the average area for the patient's age and height and interpolates between these values to determine the correct area for the patient under consideration. Average values are always to be handled as rough estimates. In looking over the tables of normals for certain weights or certain ages one is struck with the number of individuals who show areas as high as 10 per cent above or below the average normal. In clinical work we deal with the individual rather than with averages.

Even though we assume these averages to be accurate for the classes of patients specified, it is not always possible to apply them in an accurate way. A patient just recovering from an attack of acute endocarditis will have lost considerable weight. A patient coming to the hospital after a break in compensation will have gained considerable weight. How are we going to look up the average cardiac area corresponding to this patient's weight? Shall we guess at what the weight should be under normal conditions? If so, we are getting into the field of rough estimations. The internal diameter of the chest does not change with emaciation or edema. It does change roughly in proportion to changes in age, weight and height. It changes with changes in position of the diaphragm. I am wondering which will prove to be the rougher estimate, the cardiothoracic ratio or the calculations compared with average normals.

Dr. Holmes. The value of any method of examination may be estimated, I think, by the test of time. In discussion of the *x*-ray examination of the heart one thing for us to remember is: Is it of any practical value?

Percussion of the heart outline is an old method and has been in use for a great many years. If it had not been of some value to clinicians, they would not still be using it. It has been demonstrated by men in this country and abroad, who have done this work for a considerable time, that the method of examination of the heart by the *x*-ray is distinctly more accurate as to size than any method of percussion; so that if percussion is of value, *x*-ray is of more value.

Dr. Martin has covered Dr. Bardeen's paper practically as I would like to have it done. I agree absolutely with what he says. I would like to add that we are dealing with the shadow of the heart and not with the heart itself. We cannot compare the roentgenogram with the actual heart; we must compare with shadows of normal hearts. We are always dealing with widely variable factors.

We have been doing this work at the Massachusetts General Hospital since 1914, and we have an average of between 5 and 10 patients a day. The patients are sent in by clinicians, and the work must be of some value or they would not send in the cases.

One other point in regard to the methods of measurement; I think the method which one adopts depends largely on what he is examining

the heart for; what he is interested in. Bardeen was interested from a purely scientific point of view, getting at the most accurate method of determining slight changes in the size of the heart. One of the things we are asked to determine is whether the change is sufficiently great to be of any real damage to the patient. Another thing the practitioner wants us to do is to see how accurate he is in his percussion. One of the principal values in determining the size of the heart is to check up the percussion. Measurement by area would be of no value to them. They want to know how far to the right the heart is from the midsternum, etc.

Dr. Payne. In regard to Dr. Bardeen's paper: I have not had an opportunity to go over it, as I shall later. There are many here who have made a more real study of these methods, and have applied them, who are much better qualified to discuss the particular methods than I am; but to me, it has always been a question of the practical value of these methods, as compared to the amount of work done.

In the first place, we have observed the different types of patients, and have seen variations of the asthenic type, with small heart barely showing beyond the vertebral border, who live and show no heart symptoms; then there is the same asthenic type with the high diaphragm and apparently large heart, who live on.

It seems a great question, that in giving heart measurements, we really express to the clinician the value of that heart muscle. Personally, I believe the question must be: What are the results, and what is this man going to get out of the heart muscle? Is his heart muscle older than the rest of his system? How much longer is it going to last him? In view of that, I frankly confess that I have never been able to bring myself to the point of these accurate measurements, because of the many factors that are not subject to mechanical measurements; the matter of change of occupation, hardships, type of family, etc.—all these things that show the physical morale of the man and his chances of fighting infections.

Dr. LeWald. Dr. Bardeen's method is valuable for certain purposes. I would say it is the most accurate method of study of the normal individual, or a relatively normal individual, to determine in that individual the change in his particular heart.

Dr. Bardeen has referred to a series of cases examined by me, that were used in the study of the aviator's heart, in order to determine whether there was dilatation of the heart, as the aviator was put in a relatively low atmosphere to simulate high altitude. For a comparative study of that sort on normal individuals, I know of no method any more accurate.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

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Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

FOURTH ANNUAL MEETING EASTERN SECTION AMERICAN ROENTGEN RAY SOCIETY

RITZ-CARLTON HOTEL, ATLANTIC CITY, N. J., JANUARY 25–27, 1923

MIDWINTER MEETING CENTRAL SECTION AMERICAN ROENTGEN RAY SOCIETY

SEELBACH HOTEL, LOUISVILLE, KY., FEBRUARY 24, 1923

CENTRAL SECTION OF THE AMERICAN ROENTGEN RAY SOCIETY

MIDWINTER MEETING

The Midwinter Meeting of the Central Section of the American Roentgen Ray Society will be held in Louisville, Ky., February 24, 1923, at the Seelbach Hotel. It is planned to have a full day's meeting, including morning, afternoon and evening sessions. A six o'clock dinner, followed by lantern slides, is planned for the evening program. We would be more than pleased to have members of the other sections meet with us.

Anyone having anything new to present at the meeting is advised to communicate with Dr. E. C. Ernst, president of the section. All information regarding the arrangement of the meeting can be obtained from the secretary, Dr. D. Y. Keith, 746 Francis Building, Louisville, Ky.

TERMINOLOGY

The Executive Council has requested that the nomenclature which was adopted at the fourteenth annual meeting of the Society, held in Boston in 1913, and published in Volume 1, 1913, be again published. The reason for this is that since its publication many others have taken up this work, and it is deemed important that they be acquainted with the nomenclature which has become not only the standard of this society, but has also been adopted by other societies and many publications.

Roentgen: To be pronounced rent-gen.

Roentgen ray: A ray discovered and described by Wilhelm Konrad Roentgen.

Roentgenology: The study and practice of the roentgen ray as applied to medical science.

Roentgenologist: One skilled in roentgenology.

Roentgenogram: The shadow picture produced by the roentgen ray on a sensitized plate or film.

Roentgenograph (verb): To make a roentgenogram.

Roentgenoscope: An apparatus for examination with the fluorescent screen excited by the roentgen ray.

Roentgenoscopy: Examination by means of the roentgenoscope.

Roentgenography: The art of making roentgenograms.

Roentgenize: To apply the roentgen ray.

Roentgenization: Application of the roentgen ray.

Roentgenism: Untoward effect of the roentgen ray.

Roentgen diagnosis: roentgen therapy: roentgen dermatitis. These terms are self-explanatory.

EXAMINATIONS OF THE NATIONAL BOARD

The National Board of Medical Examiners announces the following dates for its next examinations:

Part I: February 12, 13 and 14, 1923.
Part II: February 15 and 16, 1923.

The fees for these examinations have been continued at the reduced rate for another year. Applications for these examinations must be forwarded not later than January 1, 1923. Application blanks and circulars of information may be obtained from the secretary of the National Board, Dr. J. S. Rodman, Medical Arts Building, Philadelphia, Pa.

THE LEONARD PRIZE

The American Roentgen Ray Society is again offering the Leonard Prize in 1923, details for which appear on advertising page ix of this number of the Journal. The manuscripts submitted for the 1921 prize were of a high order of merit and covered a variety of subjects pertinent to Roentgenology. It is to be hoped that the contestants for the next prize will be equally zealous in their efforts.

BOOK REVIEWS

CONTRIBUCION AL ESTUDIO DE LOS TUMORES DE LA HIPOFISIS. By Wehrhahn R. Alejandro. 175 pages with illustrations. Santiago de Chile. Imp., Lit. y Enc. "La Illustracion," Calle Moneda, 873. 1922.

This is a splendid work on the clinical diagnosis and treatment of tumors of the hypophysis. Of special interest to the roentgenologist is the chapter by Dr. Kaplan, corresponding member of this society, on the roentgenographic sign. After a brief histological mention of the previous work done, the author gives a brief but complete summary of our present knowledge of this disease from the roentgenographic standpoint.

JAMES T. CASE.

ETUDE ANATOMO-RADIOLOGIQUE DES VAISSEAUX DE LA BASE DU COEUR VUS DE FACE. By Dr. Robert Chaperon, Assistant de Radiologie des Hopitaux. 60 pages. Paris, France. 1922.

In reviewing the classical roentgenological publications relating to the heart, and especially relating to the blood-vessels of the base of the heart, one is astounded by the difference in the descriptions given by the various authors. In normal subjects the descriptions are similar, but the interpretations vary. In pathological cases the variations are accentuated, and if one consults the works which have recently appeared, he is astounded by the still greater variations in the descriptions. Recently, there have been published several works with the object of harmonizing the various interpretations and arriving at the truth. The author refers particularly to the work of Vaquez and Bordet. In spite of these efforts, there still exist disagreements in the descriptions of the border of the median cardiovascular shadow as seen in the frontal position of the normal subject. This and similar questions relating to the vessels of the base of the heart form the subject for this work.

JAMES T. CASE.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY *visiting New York City, are invited to make the office of* THE JOURNAL (*69 East 59th Street, New York*) *their headquarters. Mail, packages or baggage may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; in this case, kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

TRANSLATIONS & ABSTRACTS

WINDRATH. A Contribution to the Question of Roentgen Therapy in Pulmonary Tuberculosis. (*Med. Klin.*, 1921, No. 26.)

The author prefers the method proposed by Bacmeister, namely, the combined irradiation with roentgen rays and the quartz lamp. For twenty days, he irradiated every other day with the quartz sunlight lamp, the first treatment lasting three minutes, and increased the treatment by three minutes at each session. Then an interval of eight days. Then the first roentgen treatment, which consists in irradiating two fields in front and two behind, through 3 mm. of aluminum, one-third of the skin erythema dose, treating one field every other day. After an interval of eight days, the second roentgen treatment; this was followed by a second quartz-lamp-sunlight treatment. In progressive cases, the treatment had to be interrupted frequently. An examination of 14 cases after about two years demonstrated a favorable result. The author considers as especially favorable cases those which are either stationary, nodular, or inclined to induration.

SIEGEL. The Technique of Roentgen Irradiation in Malignant and Benign Hemorrhages. (*Strablentherapie*, xii, No. 1.)

In order to eliminate the difficult physical measuring methods, which the author values highly, he advocates, in cases of menorrhagia, radiation at a distance over large portals of entry. He selects a portal of entry of 20 × 20 cm. and irradiates through a 0.5 mm. zinc filter at a focus skin distance of 50 cm. With a parallel spark-gap of 37 cm., at a depth of 10 cm., he obtains the ovary dose in one hour, the complete castration dose in two hours, the skin dose in three hours. In cases of carcinoma, he employs two fields, over the abdomen and sacrum, through a 1 mm. copper filter, the other conditions the same as above, with at least 150,000 volts, and obtains in a depth of 10 cm. over one area, the dose-quotient of more than one-half in eight to nine hours; and on the skin, four-fifths of the skin erythema dose. That is, with two fields, each rayed eight to nine hours, he obtains the full carcinoma dose in the depth. With this method, he lost only 10 per cent of the cases of metastatic carcinoma. In previous treatments, under similar conditions, he lost 25 per cent. The author calls this method a biologic self-measuring method, because he controls the measuring by the effect of the rays upon the function of the ovaries.

LEVY, I. H. AND HAFT, H. H. The Incidence of Cecal Tuberculosis with Pulmonary Tuberculosis. (*Am. J. M. Sc.*, July, 1922, clxiv, No. 1.)

Tuberculous colitis is by no means an infrequent complication of pulmonary tuberculosis. From 70 to 90 per cent of all pulmonary cases show involvement of the gastrointestinal tract. Practically all cases with cavities show some involvement. Any portion of the intestinal tract may be involved, but the predominating site of involvement is in the ileocecal region, 51.4 per cent being in the ascending colon. Ileocecal tuberculosis, in the early stages, at least, is difficult to diagnose by ordinary means; neither the symptomatology, the physical examination nor the ordinary laboratory findings give the necessary information. Stierlin of Basle was the first to call attention to the roentgen diagnosis of ileocecal tuberculosis. In 1911, he reported 6 cases—4 of tuberculous colitis, 1 of cancer and 1 of ulcerative colitis—in which he was unable to fill the cecum and ascending colon with the opaque meal. These cases were all operated upon and verified. In 1912, Case, in a paper discussing tuberculosis of the ileocecal region says: "Ileocecal tuberculosis is a condition which, in a certain number of cases, can be almost surely diagnosed by the roentgen-ray examination." In 1917, Pirie of Montreal made *x*-ray studies of intestinal tuberculosis and said in part as follows: "We could not show the cecum filled by a barium meal because it never did fill when tuberculous ulceration was present. Setting out with this as a working hypothesis, we examined the cases at half-hour intervals from five to twelve hours after the barium meal. We found our theory correct in each case of tuberculous cecum, namely, the cecum never filled up with the meal. Each small squirt of barium which left the ileum was quickly passed on past the cecum and collected elsewhere in the colon." It was not until 1919, when Lawrasen Brown and Homer Sampson published their work on Early Diagnosis of Ulcerative Tuberculous Colitis, that this subject received the attention that it deserved. They substantiated the work of the former observers *in toto*, and gave their observations and conclusions in a large number of patients. They used a contrast enema and noted failure of the cecum to fill. Where a barium meal was given, they noted a pronounced hypomotility, barium remaining in the stomach for seven hours and even longer. W. R. SANTE.

WATSON, W. W. Human Actinomycosis. (*Surg., Gynec. & Obst.*, April, 1922.)

The writer discusses this subject under the headings: Biological Characteristics, Origin and Mode of Infection, Portal of Entry, Pathological Features, Clinical Course and Symptomatology, Differential Diagnosis, Prognosis, and Treatment.

Under the latter heading he states: "This seems to be one disease in which potassium iodide is specific." This should be given in heroic doses, beginning with not less than 75 drops of the saturated solution, thrice daily, well diluted. This may be increased one drop daily until 125 or 150 drops daily is reached.

Surgery was found valuable chiefly in jaw and neck cases, and only where the involved tissue can be widely excised. He does not believe surgery essential except where softening and abscess formation has taken place. He found no advantage in giving copper sulphate three times daily. The cases given potassium iodide alone did fully as well.

Although radium and *x*-rays have been widely advocated as of value in treatment of actinomycosis, the writer's experience indicates that they were of value only as adjuncts to the surgical and medical treatment. Radium hastens the softening of the actinomycotic tissues, but does not alone eradicate the parasite. Pulmonary and appendical cases were treated with radium and *x*-rays in addition to potassium iodide. It was possible to arrest the disease to a certain extent, but all proved fatal eventually.

In neck and jaw cases the prognosis is good. Skin cases eventually clear up under vigorous treatment.

A. C. C.

KRETSCHNER, HERMAN L. Demonstration of Bladder Diverticula. (*Surg., Gynec. & Obst.*, April, 1922.)

Diverticula of the bladder are usually discovered during cystoscopic examination. The size and extent of the diverticula may be demonstrated by cystography, but this sometimes fails because of the position of the diverticulum. When this happens, an opaque catheter may be passed into the diverticulum and the latter filled with the opaque medium through the catheter. In addition to this, the writer has then injected the bladder with air in order to secure sharper definition of the diverticulum.

A. C. C.

QUICK, DOUGLAS A., AND JOHNSON, F. M. Radium Treatment of Parotid Tumors. (*N. York State J. M.*, July, 1922, xxii, 7, 297.)

The problem of successfully combating parotid tumors has always been to the surgeon a difficult task. The limiting capsule of many parotid tumors is a snare, and if grossly injured, as it easily is, malignant cells which are restrained by nature's barrier are sown in the tissue, take root and grow. Sistrunk of the Mayo Clinic, in reporting 103 cases operated upon with twenty-eight recurrences, states that in practically every case of the series the operation was an excision of the encapsulated growth, thus forcing the reader to the conclusion that his cases were all distinctly favorable and early. He concludes that surgery is the only form of treatment, radium having little effect.

The authors declare that on the same type of tumor radium always performs its task in the same way. If efficiently used, its value is not disputed in skin lesions, in cancers of the mucous membranes of the mouth and in uterine growths. There are no anatomical or biochemical reasons for believing that parotid tumors behave differently from all others. In fact, they have generally been found highly susceptible to radium. At the Memorial Hospital, during the years 1918–1921, 59 cases of parotid gland tumors were treated. Twenty per cent of the cases were considered operable. No growth showing deep fixation, skin involvement, or metastatic nodal involvement, has been considered anything but inoperable. The cases were about equally divided between the sexes, occurring with slightly greater frequency in females (53.7 per cent). Half of the cases had been operated upon elsewhere with recurrences which appeared from six weeks to six years after operation; 51.9 per cent of the cases were primary. In reviewing the histories of the operated cases, it seemed evident that the malignant characters were increased by repeated attempts at removal. Only two of the operated cases were benefited.

The preliminary phase of the radiation treatment as carried out by the authors involved an external radiation of about 2,200 mc. hours, the emanation being 3 cm. from the skin surface; filter, 0.5 mm. of silver and 2 mm. of brass. Applicator 24 sq. cm. Such applicator gives skin erythema over an area of about 50 sq. cm. For very large tumors a dose of 9,000 mc. hours at a distance of 6 cm. may be used, the filter remaining the same, but the area of the applicator increasing to about 77 sq. cm. For most lesions the above

dosage is not sufficient, especially for the firm mixed tumors which contain abundant fibrous tissue or cartilage. For these and for unresponsive carcinomas, the authors use unfiltered glass tubes of emanation, 3 mm. in length, about 0.3 mm. in diameter, containing usually 1 to 1.5 mc. The insertion of these glass tubes is preferably done through a skin incision. In two cases, the authors produced paralysis of the seventh cranial nerve. Successful irradiation is followed clinically at first by hyperemia of the overlying tissue, and swelling and softening of the tumor. As fibrous tissue is produced, the tumor becomes smaller and firmer, and if it originally was of a cellular type the anticipated result would be a very small fibrotic inert mass. These changes occur during many weeks after treatment, and it is therefore important not to repeat the dosage too soon. The authors firmly believe that fibrotic masses remaining after treatment should be observed frequently, but not removed.

Results for four years ending 1921 may be tabulated as follows:

	No. of Cases	*Clinically Free of Disease*	*Improved*	*Unimproved*
Primary Operable.....	8	7	1	0
Primary Inoperable...	20	7	7	6
Recurrent Operable...	3	3	0	0
Recurrent Inoperable	23	5	8	10

The authors conclude that in the case of mixed tumors, if the case is favorable for excision, it is likewise favorable for radium therapy, and the latter does not predispose to recurrence or the production of metastases. If the tumor is inoperable, radium offers an opportunity that may lead to improvement or clinical cure. In carcinomas, whereas surgical results are very disappointing, radium treatment affords a reasonable hope of disease control or clinical cure.

Pfahler, George E. Radiotherapy in Carcinoma of the Breast. (*Surg., Gynec. & Obst.*, Aug., 1922, xxxv, pp. 217–226.)

The author describes his roentgen technique for ante-operative treatment as follows: Three areas are defined by drawing a horizontal line across the front of the chest on a level with the lower border of the axillary fold and another horizontal line posteriorly at the level of the spine of the scapula. The area above these lines is the supraclavicular area to be treated. The area below the anterior line is the mammary area to be treated, and has the mid-axillary line for its posterior limit. The third area is below the posterior horizontal line. He treats over each of these areas through 6 mm. of aluminum at 40 cm. distance, using a 9 inch spark-gap, for forty minutes, all the areas being covered within a week. The three areas are again given the same dose during the second week, so that each area receives its two doses a week apart.

Dr. Pfahler draws the following conclusions:

1. It has been shown that thorough radiation treatment of cancer tissue will devitalize the cancer cells so as to interfere with their inoculation or further development. This justifies our recommendation of ante-operative treatment.

2. It has been shown that radiation effects are most evident on new growing tumor, and that such radiation will prevent the growth of inoculated tumors. Therefore, we recommend active postoperative treatment in cancer of the breast.

3. Visible and palpable recurrent metastatic cancer are probably only an index of similar disease elsewhere, and therefore, the treatment of these cases should not be confined simply to the palpable and visible disease. Such visible and palpable disease should receive the most active treatment, and a sufficient amount to cause its destruction and disappearance.

4. Thorough radiation treatment will cause the disappearance of tumor tissue in some cases and, therefore, can be recommended when there is any reason for avoiding an operation.

5. In every case of cancer of the breast, there should be an *x*-ray examination of the chest, and this should be repeated from time to time to detect any possible invasion of the mediastinum or lungs, sternum, or spine.

James T. Case.

Carman, Russell D. Limitations of Roentgenologic Diagnosis. (*N. York State J. M.*, July, 1922, xxii, 302.)

A scholarly presentation of the present value of the roentgen rays in diagnosis. This is another example of the fact that roentgenologists have pointed out their limitations quite as freely as other medical workers. The essayist especially refers to the limitations of the roentgen diagnostic method in pulmonary tuberculosis; in the pathological differentiation of thoracic tumors; in the differential diagnosis of osteomyelitis, tuberculosis, sarcoma, syphilis, metastatic malignancy, and Paget's disease; in the differentiation of gastric carcinoma from gastric syphilis; in the differentiation between a small cancer, gastric ulcer near the pylorus, duodenal ulcer with adhesions, and a syphilitic lesion near the pylorus; and especially in the diagnosis of adhesions, chronic appendicitis, gastroptosis, enteroptosis, stasis, gall-stones, and disease of the gall-bladder.

NUZUM, FRANKLIN R. The Pathology and Bacteriology of Excised Tonsils and the Effect of *X*-ray Therapy upon the Bacterial Flora of the Tonsils. (*Calif. State J. M.*, July, 1922, xx, 237.)

Seven per cent of 218 pairs of tonsils removed presented no microscopic evidence of disease. Ninety-six and one-tenth per cent of this group of 218 pairs of tonsils harbored hemolytic streptococci. Of the three groups of hemolytic streptococci, Alpha, Alpha prime and Beta, the last were found much more frequently. There seemed to be a relation between the pathology of the excised tonsil and the type of organism it harbored. Roentgenotherapy was effective in reducing the size of tonsils in but 16 per cent of this series. Hemolytic streptococci, the essential organism in chronically infected tonsils, were permanently removed in but 50 per cent of the patients treated.

NIELSEN, N. AAGE. About the Choice between Medical and Surgical Treatment of Ulcus Ventriculi S. Duodeni. (*Acta Chir. Scandinavica*, July 15, 1922, lv, No. 1.)

A review of the literature shows that it has never been possible to state the frequency of carcinoma ex ulcere; in fact, its existence has not even been demonstrated definitely.

The present material does not indicate that ulcus simplex ventriculi s. duodeni has any tendency to become cancerous. It could not be proved during a period of observation of two and one-half to nineteen years that 221 patients with ulcus symptoms which were clinically certain and of several years' duration, had any special tendency to gastric cancer.

The disease, which has formerly been considered as carcinoma ex ulcere, is a primary ulcus-simulating cancer. The symptoms appear almost always after the thirtieth year, and develop in the course of a relatively short time into a serious clinical "ulcus picture," on which the effect of a medical ulcus treatment is poor, or but of short duration; and have caused death in the cases here examined, in the course of one to five and one-fourth years after the first appearance of the symptoms.

This cancer may often be clinically distinguished from ulcus simplex with so great a probability that an operative removal of the ulcer is justified.

JAMES T. CASE.

KOLISCHER, G. Surgical Diathermy and Radiotherapy in Cancer of the Uterus. (*Surg., Gynec. & Obst.*, Aug., 1922, xxxv, pp. 227–229.)

The author's experience leads him to believe that the best method of treatment of uterine cancer is electrocoagulation, followed immediately by *x*-ray or radium therapy.

He offers arguments in support of the theory that the beneficial action of radiation on cancer is not due to a direct destructive effect on the cell, but to the production of certain materials which in time produce defensive ferments which act on the tumors.

The aim, then, should be the removal of the "decayed and decaying cancer cells," and the production of a real chemotherapy by stimulation of the virile cancer cells to the production of ferments.

JAMES T. CASE.

MÉRY, DÉTRÉ and DESMOULINS. Radiodiagnosis of Gangliopulmonary Tuberculosis in the Child. (*Presse Méd.*, March 19, 1921, xxix, 23.)

The clinical diagnosis of this affection should always be checked up by radiography, for the latter resource is suited for giving exact information about the lesions of the hilus which are not readily accessible to physical diagnosis. When one is a little self-hypnotized about the apices it is radioscopy which brings out the hilus lesions. From initial radioscopies followed by radiography with breath held, it is very often possible to obtain ramified shadows in the hilus which stand out in plain relief from the lung and are almost always reinforced by minute lenticular spots. These shadows formerly perplexed the roentgenologist: in 1904, De la Camp thought them to pertain to the normal bronchovascular pedicle. In 1907, Sturtz interpreted them as due to peribronchitic lymphatic infiltration with minute calcified ganglia. A year later, Rieder gave the correct interpretation. Today, we admit that the bronchovascular pedicles are normally visible as discrete shadows (at least on the screen); and that peribronchitis of whatever kind reinforces and extends the faint and circumscribed pedicular shadow; and that finally sclerosis or calcification gives a still better definition. It is natural to connect with these shadows the interbronchial ganglia which are seen on autopsy to be hypertrophic, tuberculous or calcified—satellites of the mediastinal glands—but the general result is the same, for in either case we are dealing with the same process and the differentiation adds nothing to our basic diagnosis.

In radiodiagnosis of ganglionopulmonary tuberculosis of the child, the authors isolate a first degree in which hilus shadows are seen with disconcerting frequency in routine examination. The children with such shadows may

give a negative skin reaction. They are not necessarily indicative of tuberculosis, for they are seen after whooping cough and measles. Later, the shadows are ramified as in the first degree and may be no broader, but they are more entangled, and especially softer. The image shows great variability in the individual case, but common to all is the infiltrated character which indicates an active process, when there can be no doubt as to the tuberculous nature. The neighborhood reactions may or may not be extensive. But in this second degree the tendency is invariably to recovery, although in the individual case death may follow from lesions elsewhere (peritonitis). In the third degree the shadow loses its soft character and becomes again clean and distinct. The ramifications are darker and show spots of calcification, which may be in fine groups or so large and distinct as to resemble foreign bodies. Calcifications are indelible traces of tuberculosis. The phenomenon of aberrant calcification outside the hilus area is occasionally visible as a single isolated spot which indicates a distinct inoculation of tuberculosis somewhere in the lung; this focus was the parent lesion of the tracheobronchial adenopathy.

KOHLMANN. Clinical and Roentgen Diagnosis of Multiple Myelomata. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, xxviii, Heft 1.)

The author cites 3 cases of multiple myeloma, and discusses the differential diagnosis. As a roentgenological point of distinction from osteomalacia, he enumerates the following: 1. Osteomalacia never attacks the cranial bones; myeloma very frequently. 2. In osteomalacia, the shape of the pelvis is usually that of the heart in playing cards; with myeloma there are no changes. 3. Osteomalacia presents diffuse absorption of the calcium salts in the bones; myeloma presents numerous circular areas of transparency of small size. 4. In osteomalacia, there is pliability of the long bones and consequent change in form; in myeloma, the contours are well preserved and there is tendency to spontaneous fracture. Difficult is the differential diagnosis between myeloma and osteoclastic carcinomatosis: in myeloma, the transparencies of the bone are more sharply circumscribed than in carcinoma, the process is more diffused, all ribs, the scapulae, the pelvic bones are affected; in carcinoma the lesion is rarely so extensive. In sarcoma, the corticalis is thinned out and expanded, which is not the case in myeloma. Early diagnosis by means of the *x*-ray is possible, and is of great value for its treatment.

WERNER AND GRODE. The Present Status of Radiation of Malignant Tumors. (*Ergebn. d. Chir. u. Orthop.*, 1921, xiv.)

The fundamental requisites for radiation therapy of malignant tumors are apparatuses which will generate the hardest possible rays and the greatest intensity. To this type belongs the symmetry apparatus of Reiniger, Gebbert and Schall (Erlangen), the intensive reform apparatus of Veifa-Werke (Frankfort-on-the-Main), and the radio-silex apparatus of Koch and Sterzel (Dresden). These apparatuses are constructed on entirely new principles. The most important innovation in the methods of measuring is that of Glocker and Reusch. It consists in measuring the ionization with a mirror-galvanometer instead of an electroscope. By this means, the intensity of the radiation is determined during the entire period of treatment. Every change is at once apparent, and, by regulation, the same surface doses per second can be obtained.

The intensity of the biological effect of roentgen and radium rays, according to Krönig and Friedrich, is dependent only upon the absorbed radiant energy. It is, within very wide limits, entirely independent of the hardness of the rays. With the equal dosage, the effect is stronger if the radiation is given during a short time with higher intensity, than during a long time with lesser intensity. The effect of the gamma rays of radium or of mesathorium filtered through 1.5 mm. of brass and 5.0 mm. of celluloid is virtually the same as the effect of roentgen rays filtered through 1.0 mm. of copper. The authors recommend treatment with radium alone only in superficially situated small tumors, and, in the cases of the large ones, only in places where the concentric roentgen radiation is practically impossible.

Clinical experience would suggest more frequent experiments with irradiation in brain tumor cases, inasmuch as a large number of curative results have been reported. In early cases of carcinoma of the tongue, the best results are promised by operating, and then irradiating afterwards. In cases of carcinoma of the esophagus, irradiation with radium and roentgen rays resulted in improvement for only a short time, excepting in one case. Cases of gastric carcinoma reacted favorably in a very few instances. Carcinomata of the colon, operated on radically and then systematically irradiated, remained, in almost all instances, free from recurrence. Prevention of recurrences in carcinoma of the breast could not be achieved. The usefulness of roentgen therapy, however, is shown by its potency to cause the disappearance of recurrences and to

produce cures which have lasted several years. The most rational method appears to be the following: First, a thorough extirpation of the carcinoma; then in the first year, irradiation five to six times, in the second year, three to four times, and then two or three times, according to circumstances. In cases of carcinoma of the uterus, the question is whether one should merely irradiate, or operate and then irradiate. According to the statistics of Warnekros, there were, during a period of observation extending from three to six years, 55 per cent of recurrences without postoperative irradiation, and 18 per cent of recurrences with postoperative irradiation. Seitz and Wintz found that after three years, only 25 per cent of the patients suffering from uterine carcinoma, who had not been operated upon, but who had been treated by combined radium and roentgen rays, were alive. From this the conclusion can be formed that surgical operation represents a momentary greater risk, but gives better chance for permanent cure. The carcinoma and sarcoma doses as advocated by Seitz and Wintz can be accepted only as the lower limit, because even 200 and 250 per cent of the skin unit dose were not sufficient, in some cases, to destroy the tumor tissue. For this reason, radiation therapy challenges surgery only in cases of skin epithelioma, carcinoma of the pharynx and of the larynx (above the vocal cords), carcinoma of the mucous membrane of the cheek, of the lips, and in lymphosarcoma. Very frequently the value of postoperative irradiation is quite evident, especially after incomplete operative procedure. The limits of irradiation are indicated by the patient's general condition, the drop of leukocytes to below 2,000, blood changes, and serious damage of the neighboring connective tissue. Inasmuch as sufficient radiosensibility occurs only in some of the malignant tumors, and histological appearances can give us no clue, every irradiation of a malignant tumor becomes more or less of an experiment.

Isaak. Multiple Myelomata. (*Ergebn. d. Chir. u. Ortbop.*, 1921, xiv.)

The clinical picture frequently remains indefinite up to the patient's death, and the diagnosis is made only at autopsy. Roentgenograms, however, frequently give important diagnostic points: fractures and infractions, change in the structure of the bones, thinning of the corticalis, disappearance of the spongy portions. Instead of the spongiosa, there are found partly circumscribed, partly more diffuse, transparencies. The author believes it impossible to differentiate myelomata from secondary tumors of the bone-marrow. For treatment, he proposes roentgen radiation, intravenous injections of thorium X or benzol.

(Assmann also in his book on "Roentgen Diagnosis of Internal Diseases" points out that the defects in cases of multiple myeloma are apparently somewhat better circumscribed than carcinoma metastases, but that in many cases, a definite differentiation by *x*-rays alone is not possible. According to Assmann, it is not yet settled whether the multiple myeloma belongs to the general tumors or to the leukemic diseases. In the latter, especially in the lymphatic and myelogenous leukemias, Haenisch and Querner found transparencies in the bone shadows which had greatly resembled the appearance of metastatic bone tumors. Reviewer's Note.)

Schmidt. Results of the Radiation Therapy at the Gynecological Clinic of the University of Bonn. (*Strahlentherapie*, 1921, xii, Heft 1.)

The author had similar successful results with the irradiation of sarcoma of the uterus and ovaries, as with carcinomata of the ovaries. In contradistinction to Seitz and Wintz, he first operates upon carcinoma of the uterus, and then irradiates. For the castration dose, he recommends a single session, which gives 100 per cent lasting results, while serial irradiation gives only 98 per cent. The ill effects are not more severe after a single session than they are after a series of irradiations. It is interesting to note that he induced the desired temporary sterilization in a woman of thirty-one. Menstruation recurred, as intended, after six months, and was regular and normal.

Zweifel. Radiotherapy of Myomata and Metropathies of the Uterus. (*Strahlentherapie*, 1921, xii, Heft 1.)

At Doederlein's University Gynecological Clinic, the following conditions are accepted as contraindications:

1. Very large myomata extending above the navel.
2. In cases in which it is desirable to retain menstrual function in the uterus.
3. All myomata with malignant degeneration.
4. Purulent or gangrenous myomata.
5. Subperitoneal pedunculated myomata.
6. Completely or partially prolapsed submucous myomata.
7. Myomata with tumors of the adnexa.
8. Myomata which cause compression symptoms.

Notwithstanding this very careful selection, 64 per cent of the myomata were irradiated: 438 myomata, and 320 cases of metropathies

and climacteric bleeding. It is best to irradiate during the first half of the intermenstrual period. In most instances, the tumor diminished in size, and in some, normal conditions were obtained. One patient who was treated during the fourth month of pregnancy for a myoma as large as a fist, gave birth to a normally developed, healthy child. Nurnberger estimates the frequency of deformities of irradiated foeti at 3 per cent.

SIEGEL. The Length of Life of Women Suffering from Carcinoma of the Uterus. (*Strahlentherapie*, 1921, xii, Heft 1.)

The author believes that the end result of radical operations, such as Wertheimer's total extirpation, is not better than that of the less radical procedures. He recommends that uterine carcinoma should be rayed in institutions only which are equipped to measure exactly the applied *x*-ray or radium dosage by means of the iontoquantimeter. Otherwise, he recommends operative procedure to be followed by radiation for the prevention of recurrences. Technique: distant large fields irradiation and 1 mm. copper filter.

WERTHEIMER, SELMA. Metastases from Irradiated and Non-irradiated Carcinomata of the Cervix. (*Strahlentherapie*, 1921, xii, Heft 1.)

Fifty-four irradiated and 50 non-irradiated cases, among which there were 32 postoperative cases of carcinoma of the cervix, were particularly carefully examined at autopsy for metastases. In cases that were not rayed there were metastases in 54 per cent. In those cases that were treated by *x*-rays, radium, or by both, there were metastases in 48 per cent. This shows that radiation therapy of carcinoma of the cervix does not increase metastases. The liver, however, is unique, in that carcinomatous metastases were found in 26 per cent of the irradiated cases, and in 14 per cent of the cases not rayed.

KLEWITZ. Roentgen Deep Therapy of Internal Diseases. (*Strahlentherapie*, 1921, xii, Heft 1.)

In myelogenous leukemias, the author found irradiation of the spleen sufficient. Occasionally, he also rays the liver and the bones, but avoids forced irradiation, and ceases treating when the number of leukocytes has dropped to 20,000 or 30,000. In lymphatic leukemias, his results are frequently less favorable. In acute cases, irradiation is often without effect. Polycythemia was treated successfully; at first the long bones, then the sternum, later the spleen. With mild irradiation of the spleen ($\frac{1}{4}$ of the skin unit dose over one field) he occasionally had good success when there were hemorrhages. Pulmonary tuberculosis was rayed with a $\frac{1}{4}$ skin unit dose, size of field 10 by 15 cm., 4 mm. of aluminum, causing no ill effects. Fever was no contraindication. It was not possible to claim good results with any degree of certainty. In tuberculosis of the peritoneum, he used one skin unit dose and 4 large fields. Radiation over many fields has resulted in disastrously excessive dosage. Bronchial asthma reacted favorably to irradiation (7 fields, 10 × 15 cm., $\frac{1}{3}$ skin unit dose each). In neuralgias, he had good results in only a few cases; in chronic articular rheumatism, there were frequently very brilliant results, and just as frequently poor ones, but the relief from pain was noted in almost every case.

JÜNGLING. Treatment of Sarcoma with Roentgen Rays. (*Strahlentherapie*, 1921, xii, Heft 1.)

According to extensive statistics, 20 to 25 per cent of sarcomata remained unaffected by radiation therapy. It is true that sarcomata which disappear as the result of radiation do not recur, but this method does not protect against metastases. Cachexia in sarcoma is not the contraindication to radiation that it is in carcinoma. In sarcomata of the skin, one can always at first try radiotherapy. On the other hand, sarcomata of the upper jaw are the poorest cases for radiation. For this reason, operable cases should be operated upon. Lymphosarcomata occasionally disappear after the application of 30 per cent of the skin unit dose. Even in sarcoma of the pelvis, very astonishing results have frequently been obtained. Sarcomata of the extremities must be very sharply divided into periosteal and *myelogenous;* the latter are relatively benign, consequently they can be resected. In periosteal sarcomata, surgical means are powerless; consequently an attempt at irradiation should be made. This, however, must be of the homogeneous type.

BACMEISTER. The Roentgen Therapy of Pulmonary and Intestinal Tuberculosis. (*Strahlentherapie*, 1921, xii, Heft 1.)

The solid foundation for the roentgen treatment of pulmonary tuberculosis was created only through the experimental work of Küpferle and Bacmeister, who demonstrated that even in pulmonary tuberculosis, the tuberculosis granulation tissue can be transformed by radiation into scar tissue, while the tubercle bacilli are not affected. Where the granulation tissue recedes, roentgen therapy

is powerless, so in all acutely progressive and acutely destructive processes it can only aid the natural process of healing, and stimulate and increase scar formation. For this reason, the type of the pulmonary tuberculosis must be determined before the irradiation treatment by exact clinical observations and by roentgen diagnosis; radiation of ambulatory cases must be avoided. Only the slowly progressive, the stationary, and those forms of the cerotic and nodular tuberculosis which have the tendency to become latent, are adapted for radiation. Not only the indication for treatment, but also the technique, is very important. The stimulating effect for the development of connective tissue is the result to be obtained. The author employs the 4 mm. aluminum filter, large areas, small doses (8 to 30 per cent of the skin unit doses) up to 5 fields from in front as well as from behind, and long intervals for the reaction. He warns against over-enthusiastic hopes, but he considers the roentgen treatment of pulmonary tuberculosis a very valuable aid in the treatment at sanatoria, which cannot be replaced by anything else. He has also had very good results in intestinal tuberculosis. His technique is 20 to 40 per cent of the skin unit dose, 4 large fields, 4 mm. of the aluminum filter.

BRYANT, JOHN, Visceral Adhesions and Bands; Normal Incidence. A Preliminary Report. (*Am. J. M. Sc.*, January, 1922, clxiii, 1, p. 75.)

The frequency of occurrence of adhesions or bands in the fetus of both sexes has been greatly underestimated. Of a group of 34 fetal cases of both sexes, only 5.9 per cent were free from demonstrable adhesions or bands: 100 per cent of the 18 male feti showed such variations from the normal.

The adhesions present in the fetus are less varied in number and of a definitely less complex type than those found to occur in later life.

The age of forty is critical in both sexes. There is practically no increase in frequency above the fetal rate of involvement for the different viscera by adhesions until the age of forty. Beyond the age of forty, there is a sudden increase of about 50 per cent in the involvement of the different viscera by adhesions in both sexes, the increase being somewhat more marked in the female than in the male.

The two actual adhesions or bands found to occur most often in both sexes at all ages are, in their order of frequency, as follows: (*a*) Gall-bladder to the duodenum and to the transverse colon in both sexes; (*b*) gall-bladder to the transverse colon in the male and the gall-bladder to the duodenum in the female. In both the male and the female fetus the two adhesions or bands most frequently found were: (*a*) Gall-bladder to the duodenum and to the transverse colon; (*b*) gall-bladder to the transverse colon. It would therefore appear that these two most frequently occurring adhesions or bands are of congenital or developmental origin.

The regions or quadrants of the abdomen most frequently involved by adhesions or bands in both sexes are, in their order of frequency, as follows: Right upper quadrant, right lower quardant, left upper quadrant, left lower quadrant.

KUMER, L. The Management of Roentgen and Radium Ulcers (Ein Beitrag zur Therapie des Rontgen und Radiumulcus), München. med. Wchnschr, Aug. 6, 1921, lxviii, p. 1084.

The radical treatment of roentgen and radium ulcers is excision with subsequent sliding skin flap or skin transplantation to cover the defect. This method, however, can only be used when the ulcer is favorably located, and in some cases it develops into a rather serious surgical intervention. In the clinic of Prog. Riehl, continuous water baths have been used for a long while. Sacken also reports good results with this method. The purpose of the treatment is to prevent diseased parts from contact with any irritating substance. The relief from pain is very marked. Continuous submersion in warm water hinders necrosis by permitting much better blood supply to the diseased parts. Wetterer has employed fomentations with water containing hot camomile. Bettmann reports favorable results from the use of physiological saline solution, both as a douche and as a fomentation.

WETTERER. Roentgen Treatment of a Few Complications of Gonorrhea. First Experiments with Acute and Chronic Gonorrhea. *Strahlentherapie*, 1921, xii, Heft 2.

Wetterer had for several years observed a favorable effect of the roentgen rays upon gonorrhoic processes in the vicinity of the urethra, and upon gonorrheal prostatitis, especially paraurethritis, and he consequently decided to irradiate the penis as well as the female genital organs in cases of acute as well as chronic gonorrhea.

For gonorrheal arthritis, roentgen therapy is of great value. All joints react similarly well; in cases of hydrarthrosis there must be several prophylactic radiations after the exudate has been formed. Prognosis is best in acute and

subacute cases, but also the chronic and even protracted cases are likely to improve under the treatment. Periostitis blennorrhoica reacts favorably as long as the focus still retains a doughy feeling. In 75 cases of gonorrheal disease of the organs of locomotion, the author did not have a single failure. In most instances the result was astonishing. Adenitis blennorrhoica reacts favorably to radiation whenever it has to be radiated. Gonorrheal prostatitis is one of the best indications for roentgen therapy; the acute as well as the parenchymatous forms are generally very favorably influenced. The chronic form, of course, requires longer intermittent treatment, but is also favorably influenced. Potential coeundi can become normal again. In gonorrheal inflammation of the seminal vesicles there is a rapid resolution, but in gonorrheal epididymitis, the result seems doubtful to him. On the other hand, paraurethral infiltrations and abscesses are very favorable for radiation. Among the complications in women, gonorrheal salpingitis and oophoritis were strikingly improved. In one case the author could not yet make any definite statement as to the duration of the result. Acute gonorrheal urethritis and gonorrhea of the cervix were the more easily favorably affected, the earlier the case came for treatment. In the male, the end result appeared, as a general rule, more quickly than usual, although at first there was the marked reaction of irradiation. In the cases which are radiated early, the processes never extended to the posterior urethra or the prostate. Chronic gonorrheal urethritis with extensive infiltrations in the mucous membrane and with granulations in a very favorable object for experiments with roentgen rays. In cases of acute and chronic gonorrheal inflammations of the cervix, Wetterer saw several favorable cases as well as absolute failures. The provocation of gonococci by roentgen rays in the male as well as in the female, owing to the produced inflammatory reaction, was successful even in such cases where bougies, stretching, arthigon had failed. The irradiation was made with a filter of 1 mm. cu., 1 mm. Al. and a sheet of celluloid. Technique was practically the same as in gynecology. The dosage was not quite as high as in gynecology; it was a little below the erythema dose.

RIEDER. Prevention of the General Disagreeable Symptoms after Deep Therapy (Roentgen Sickness). *Strahlentherapie*, 1921, xii, Heft 2.

The cases of roentgen sickness, according to the author, are not only due to toxemia by ozone, but also to changes in the deep tissues due to electric charges. If the patients were grounded, irradiation was borne considerably better. In order to avoid electric shock through the grounding, it is necessary to make a broad and safe contact between the patient and the earth. The elastic metal band was applied directly to the skin of the limb of the patient, but this was applied only if the focus skin distance was at least 40 cm.; otherwise the possibility of discharge from the tube to the patient could not be definitely avoided. The grounding cable must be at a distance of at least 70 cm. from the high-tension wiring. It is also unsafe for the patient if the axis of the tube cathode is parellel to the axis of the body. This is surely so at the focus skin distance of less than 60 cm. With this precaution (grounding) and by exposing to irradiation as small segments of the body as is possible, which can be accomplished by the Holfelder method, roentgen sickness was avoided in cases of prolonged irradiation. The exceptions to this were only cases of irradiation of the splanchnic area, but here very large doses of laudanum-scopolamin were of great assistance, because they stopped vomiting and roentgen sickness. Even for long radiation laudanum-scopolamin proved an excellent narcotic which has a soothing effect upon the center of vomiting.

SCHRÖDER. Regarding the Treatment of Pulmonary Tuberculosis with Roentgen Rays. *Deutsche med. Wchnschr.*, 1921, No. 45.

Early cases, principally, should be treated. Chronic cases, even though they may present evidence of slight destructive processes, should be treated, but only if scar formation has begun to appear. The effect desired is the biological increase in the activity of those cells which cause formation of connective tissue, but do not cause disintegration of the diseased tissue. This effect can be obtained by stimulating doses. Fraenkel rays, with stimulating doses, the foci in the lungs and the spleen simultaneously. According to him, the spleen is the more important organ because it forms antibodies and fat-splitting ferments, a process which may be accelerated by stimulating doses. The author has checked up animal experiments made by Küpferle and Bacmeister, but he chose for infecting the guinea-pigs the bovine type of the tubercle bacillus and not, as Bacmeister did, the less virulent human type. In very extensive experiments which were modified in various ways, the author infected the guinea-pigs, partly subcutaneously, partly intravenously, with .1 mg., and later, .05 mg. of the virus, and rayed the animals at varying intervals with $\frac{1}{3}$ to 1 skin erythema dose. The comparison of the

control animals which were infected but were not rayed showed no effect upon body weight or length of life of the animals. Autopsy findings showed no perceptible difference, but the favorable effect of the irradiation was distinctly recognizable in the cases of tuberculous adenitis produced experimentally. In the animals which had been rayed with large doses, there were at the site of the infection small hard nodules up to the size of a bean, and in the control animals there were caseous nodes varying in size from a plum up to a small apple.

For the clinical experiments, 11 patients with relatively benign chronic types were selected. Radiation: one field at intervals of two to three weeks, 0.6 to 1.0 skin erythema dose per field was given. Three patients were simultaneously treated with pneumothorax, 7 with careful vaccinations, 3 by irradiation with the quartz lamp. Although the author frequently obtained the impression that retraction of the tissue was stimulated, no really favorable effect was obtained by roentgen therapy. In a few cases he saw injurious effects, which should cause us to be very cautious. For this reason, he considers it more advisable to use the stimulating doses suggested by Bacmeister, in order to work with less danger to the patient. In tracheobronchial tuberculosis, however, the author had undoubtedly good results.

HULDSCHINSKY. The Treatment of Rachitis with Ultraviolet Rays. *Zeitsc. f. Orthop. Chir.*, 1920, xxxix.

In view of the very favorable results, the author is of the opinion that radiation with ultraviolet light is a specific in the therapy of rachitis. All children from one and a half to six and a half years, suffering from rachitis in varying degrees, who were treated with ultraviolet rays, were cured in two months. All told, there were 22 to 26 treatments. Huldschinsky considers this assertion proved by means of extensive *x*-ray examinations; the roentgen findings serve as a test of the process of healing; calcareous or osseous deposits and new-bone formation were demonstrated. The irradiated children showed a tendency to healing after one month, which became very marked at the end of two. One child had been in the hospital already ten months suffering from severe rickets which resisted all therapeutic methods; aside from the physical findings, the patient made the impression of a complete idiot, but in two months of irradiation rapid mental and physical improvement was shown. The author used a quartz mercury lamp (artificial alpine sun) without filter. In determining dosage, one must attempt to avoid that the patient becomes accustomed to the rays. As soon as the result is obtained, treatment should be interrupted, and should be begun again with small doses after eight to fourteen days. The author believes that intensive initial treatment promises better result. He believes that the effect of natural sun rays can be an obstructive one, owing to the formation of pigments. For orthopedic surgery this method is of especial importance, because in acute rickets surgery can be employed at any stage if there is postoperative radiation. The plaster cast is no obstruction to the rays; if it is removed four weeks after operation the fracture will be found healed and the bones sufficiently calcified to prevent renewed deformity. The author believes that the prevalence of rickets in Germany as a result of the war and post-war years can be made to disappear completely.

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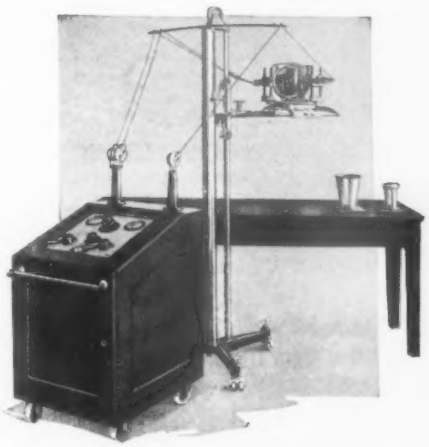

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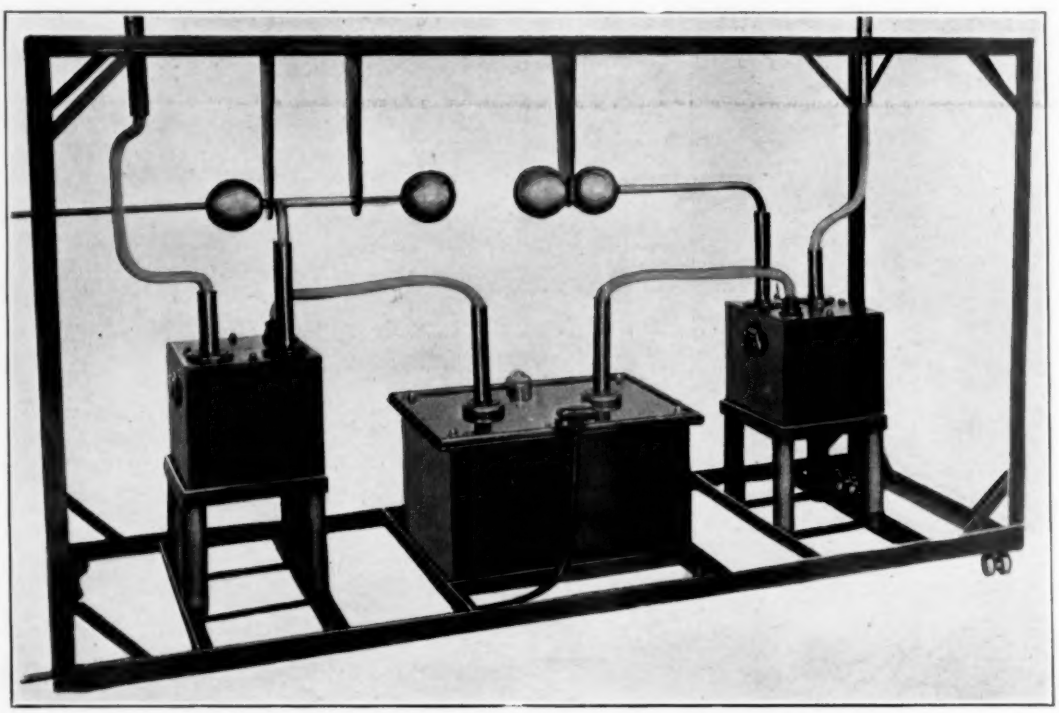

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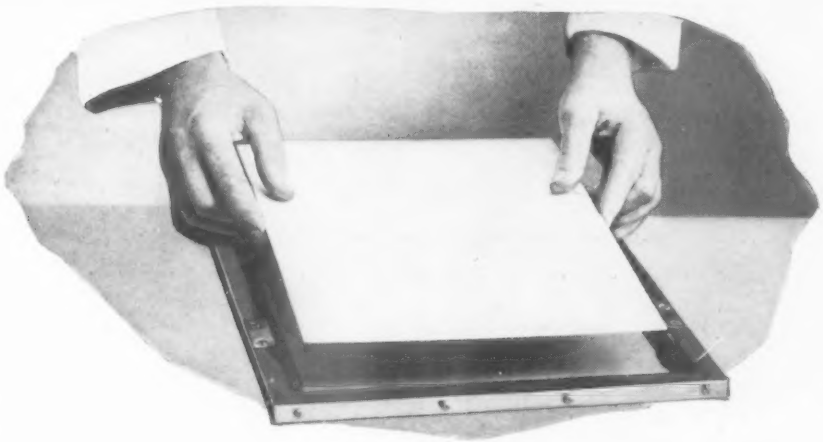

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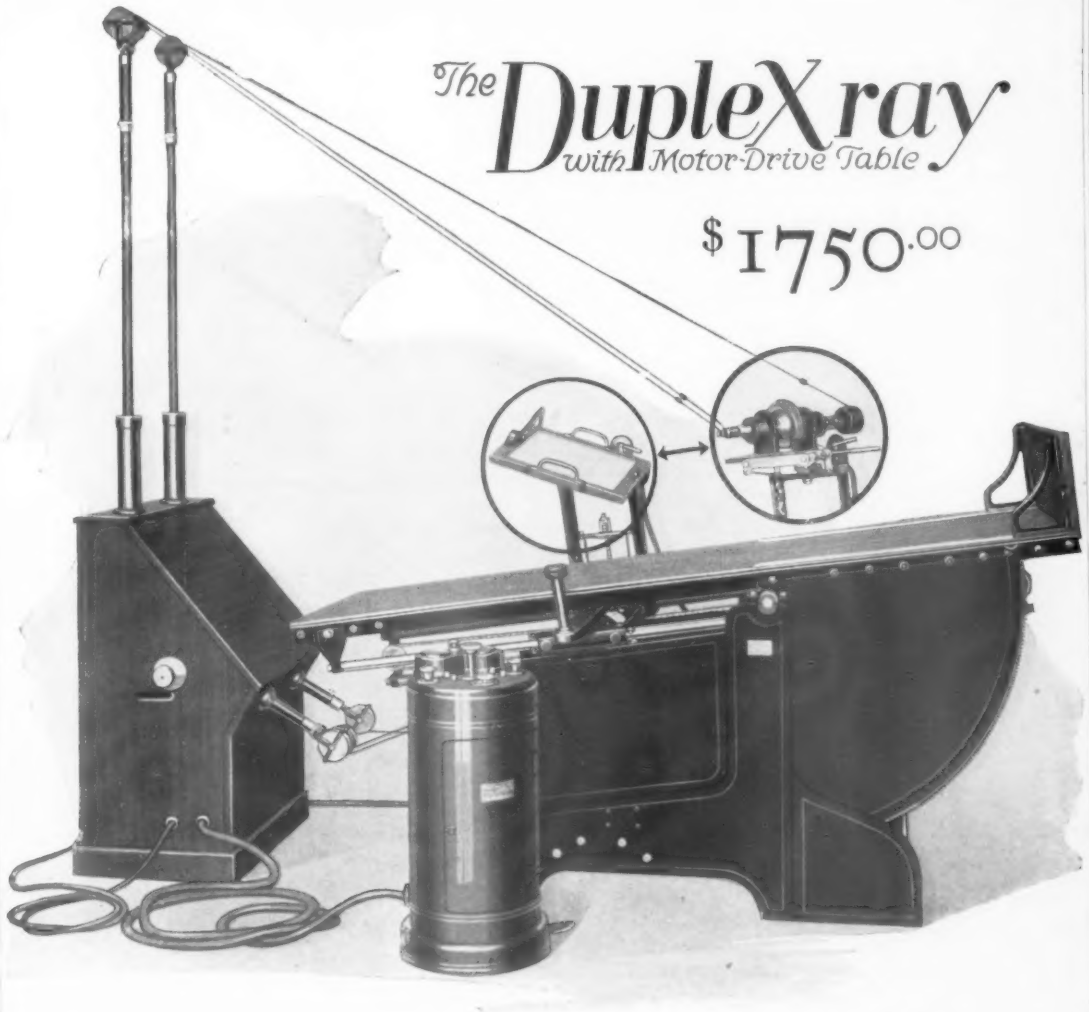

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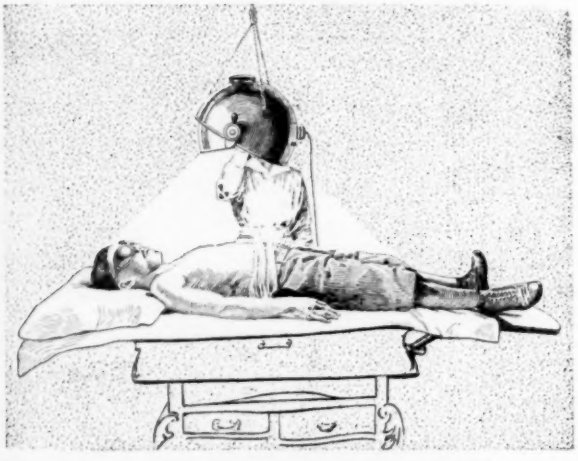

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[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

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VOL. IX [NEW SERIES] DECEMBER, 1922 NO. 12

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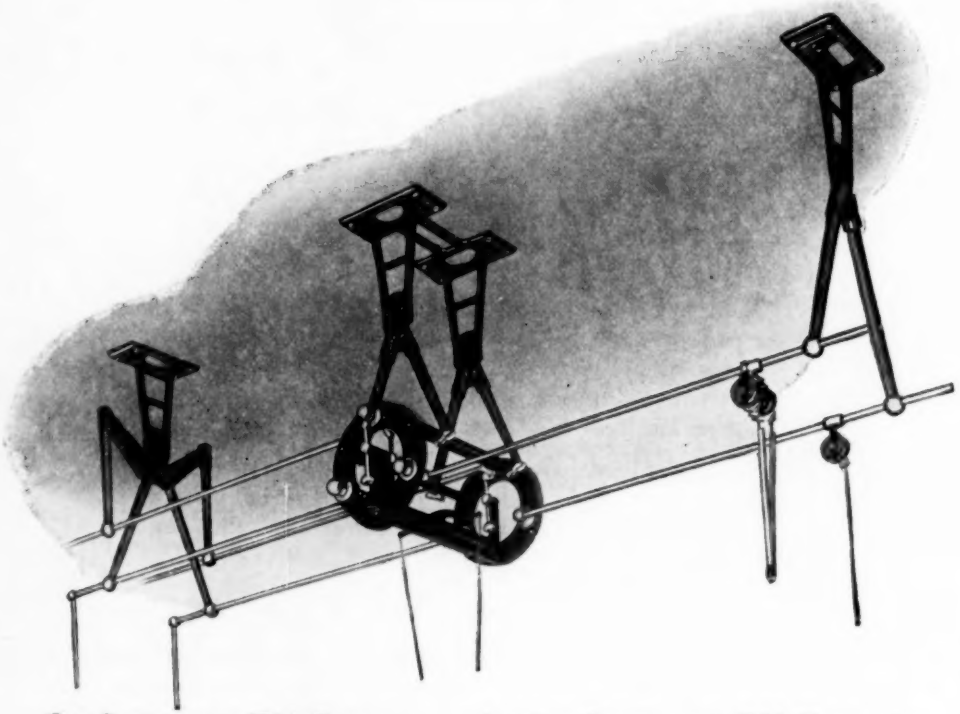

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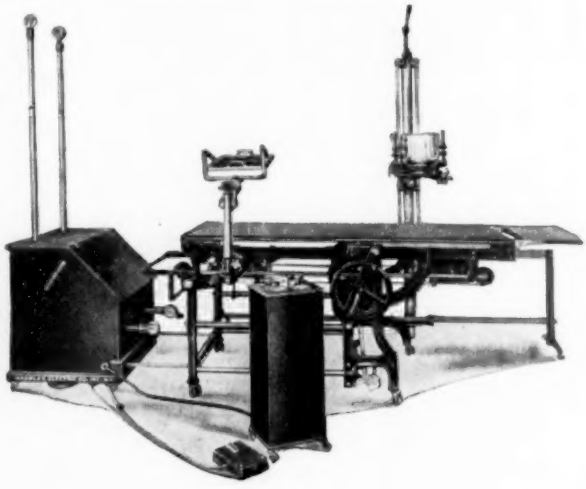

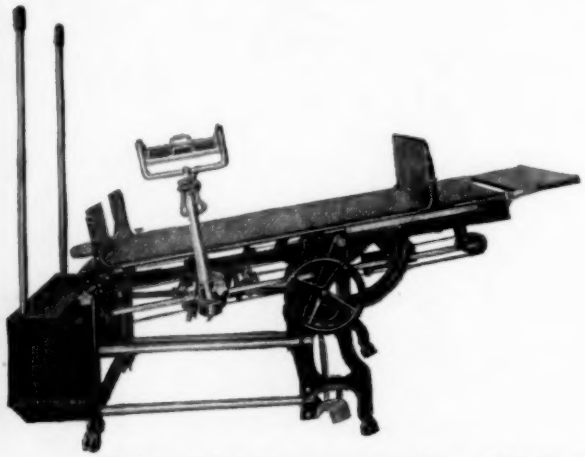

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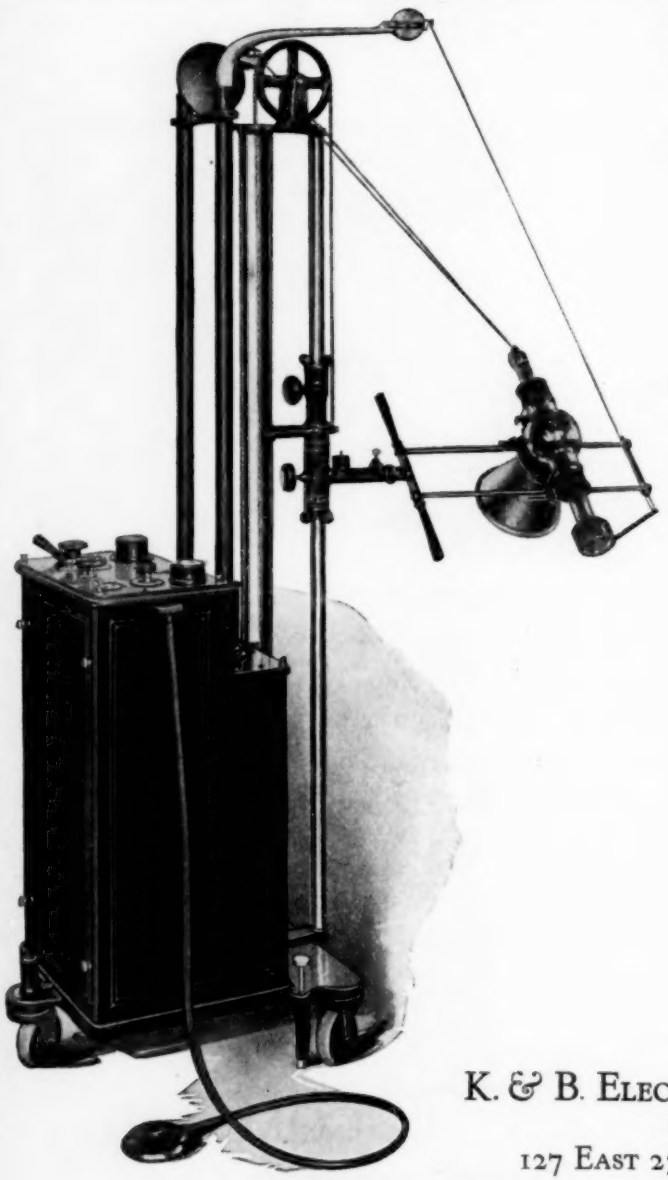

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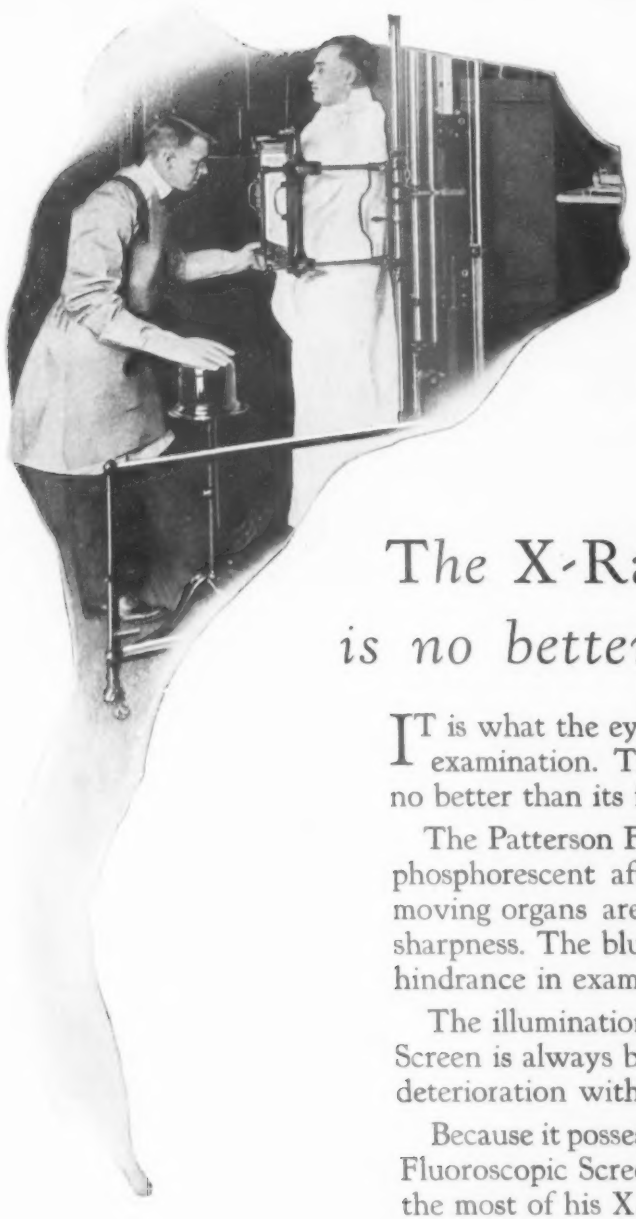

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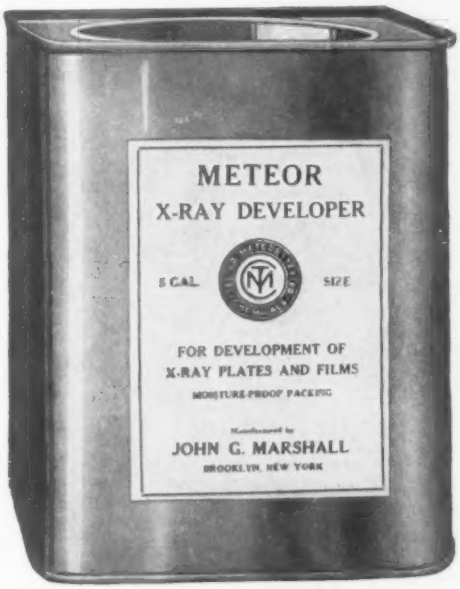

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and L. JACHES
Roentgenologist, Mount Sinai Hospital

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